S. HRG. 100–44 PT. 2

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

PART 2 (Pages 753–1698)

DEPARTMENT OF ENERGY
Power Marketing Administrations

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ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

THURSDAY, MARCH 12 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:33 p.m. in room SD–192, Dirksen Senate Office Building, Hon. Mark O. Hatfield presiding.

Present: Senator Hatfield.

DEPARTMENT OF ENERGY

POWER MARKETING ADMINISTRATIONS

BONNEVILLE POWER ADMINISTRATION

STATEMENT OF JAMES J. JURA, ADMINISTRATOR

OPENING REMARKS

Senator HATFIELD. The hearing will please come to order. This afternoon, we are to receive the testimony for the fiscal year 1988 budget request for the Bonneville Power Administration.

On behalf of the subcommittee and Chairman Johnston we extend a warm welcome to Mr. James Jura, the Administrator of Bonneville.

Mr. Jura, I believe this is your first appearance before this committee as the new Administrator of the Bonneville Power Administration, and we welcome you for this historic moment. We look forward to many more years of your appearing here.

We will place your entire statement in the record and you may proceed with your testimony at this time in any fashion you choose.

Mr. JURA. Thank you, Mr. Chairman. First, I would like to say it is my pleasure to be here. This is my first congressional hearing, and it is a pleasure to appear before you, sir.

I am here to answer any questions as best I can about our fiscal year 1988 budget. Before I do that, I do have a few remarks I would like to make about the Booneville Power Administration.

INTRODUCTION OF ASSOCIATES

Senator HATFIELD. Fine. Mr. Jura, you may wish to identify your very distinguished associates who have accompanied you here today. I must observe that over the years, those faces change a bit, and some of them look a little older and others disappear. I am looking for the old legal eagle that you used to bring with you, Bob Radcliffe.

Mr. JURA. Bob Radcliffe, our Deputy Administrator, is in Portland today taking care of the agency.

Senator HATFIELD. Would you like to make a part of the record the names of your associates here?

Mr. JURA. Yes, sir.

I would like to introduce Lee Johnson, the manager of our Washington, DC, office; Roger Seifert, the deputy of our Washington, DC, office; Steve Ailshie, our Financial Manager; Jack Robertson, head of external affairs for the agency.

Senator HATFIELD. Who? [Laughter.]

Mr. JURA. Jack Robertson; James Jones, Deputy Power Manager; John Cameron from our Office of General Counsel; Craig Mortensen and Steve Wright from our Washington, DC, office; and Joan MacNamara. I believe that is all, sir.

Senator HATFIELD. Thank you. Welcome to all of you.

REPAYMENT STATUS

Mr. JURA. Mr. Chairman, we are continuing to operate in a very interesting time, and I am here today to report that Bonneville is addressing many things, but the one issue I would like to highlight first is that we are making our scheduled Treasury payments. At this time, we are fully current in our payments to the Treasury, and I am pleased to report that we will make a full fiscal year 1987 payment of $588 million to the Treasury this September.

We also plan in fiscal year 1988 to make a full Treasury payment of $612 million. This will result in a fully up-to-date payment schedule for Bonneville. We have paid $2.2 billion to the Treasury in the last 5 years on principal and interest on the federal investment in the hydroelectric projects and transmission facilities in the Pacific Northwest. This resulted in payments of over $4.8 billion being paid on principal and interest since Bonneville was established in 1937.

REVENUE DIFFICULTIES

We are making these payments in somewhat difficult circumstances. We have experienced revenue difficulties in 1986 and are experiencing such difficulties in fiscal year 1987. We are experiencing these difficulties in all of our revenue sources, but in 1986 the problem was primarily in two of our three major revenue sources.

The first was our sales to California, which are our export sales; that is, sales of surplus power. In fiscal year 1986, those revenues were $164 million short of what we projected when we established the rates 1½ years ago.

Sales to our aluminum customers have also been off substantially. In 1986, we were $120 million short of projected sales from our direct service customers. In 1986, our sales to our other customers within the region were right on target.

However, as we go into 1987, we find that the sales to California, the sales to the aluminum industry, and now, the sales in the region are lagging somewhat.

The primary reason for the lag in sales in the region deals with the weather conditions we have experienced this year. I should also mention that these market conditions are improving somewhat in 1987, but that we expect, in 1987, to underrun our earlier revenue projections by about $300 million.

REVISED BUDGET LEVELS

Now, at the same time, we are taking actions to address this, and I will get to those actions in a moment. I would like to also mention that we continue to project a sizeable surplus of firm power. Our surplus now is estimated to be in the neighborhood of 1,800 average megawatts. We expect that will extend out in lesser amounts to the end of this century.

The key effort we are making in addressing these issues is to cut our costs. Since May of last year, we have cut over $1 billion of projected programs for fiscal years 1987, 1988, and 1989. Just before my predecessor, Peter Johnson, left, we saw the need to take this action and started to reduce the costs that were projected for those years.

Last week, as part of our ongoing rates process, I announced another round of cuts which totaled $220 million for years 1988 and 1989. This action is a result of the discussions we have had with our customers and other parties in the region as to where Bonneville should be spending money. These revised spending levels will allow us to continue to meet all of our obligations, including repayment to the Treasury, and to overcome lower revenue projections, with a 9.5 average rate increase to our preference customers at the start of fiscal year 1988.

We believe this proposed rate increase is prudent and necessary given these obligations and these circumstances. I would also like to emphasize that we are trying to do a better job of marketing our surplus power, and I hope when I am here next year to testify before you that I can tell you about ways we have found to make better use of that surplus in the region.

NEW CHALLENGES

BPA faces new challenges as it begins its 50th year of service to the region and to the nation. We are responding to these challenges by taking strong action so that we can improve our financial condition, satisfy our commitments to the Treasury, assist the Pacific Northwest in its economic recovery, and carry out all of our statutory responsibilities.

Mr. Chairman, this concludes my statement. I would be happy to answer any questions you have.

[The statement follows:]

STATEMENT OF JAMES J. JURA

Mr. Chairman and Members of the Committee, it is a pleasure to come before you today for my first time as Administrator to present the Bonneville Power Administration's (BPA) Fiscal Year 1988 Budget.

I am pleased to report that we plan to make our full $588 million payment to the U.S. Treasury for Fiscal Year (FY) 1987 and to repay $612 million in FY 1988, under our revised budget and rate proposals. Our current rate proposal will help assure that we meet these payments while carrying out our responsibilities under the Pacific Northwest Power Act.

Before I summarize the budget, I want to bring you up to date on the market conditions for energy on the West Coast, how they are affecting our revenues, and the new strategic directions we are taking to ensure that we can meet our legislated responsibilities, including our Treasury payments.

MARKET AND FINANCIAL CONDITIONS

Over the past year, revenues from two of BPA's three major customer groups -- aluminum smelters and California utilities -- have changed dramatically from previous expectations. The world price of aluminum has recovered more slowly than projected. As a result, BPA FY 1986 revenues from power sales to Northwest aluminum plants and other direct service industries were down $120 million from projected revenues of $502 million. In addition, some of BPA's other Pacific Northwest customers continue to experience difficult economic circumstances, and many parts of the region lag behind the Nation's economic recovery.

At the same time, California utilities have benefitted from the low worldwide price of oil and gas. While they continue to purchase surplus Northwest electricity, they are doing so at much lower prices than expected. In fact, during FY 1986 nonfirm energy was sold to California at prices that were considerably below the 22.2 mills/kWh level that the Federal Energy Regulatory Commission (FERC) recognized as the fully allocated cost of the power to BPA. As a result, FY 1986 revenues from all sales to California were $164.0 million lower than the $430 million projected.

These market conditions have continued to the extent that we currently expect our total FY 1987 revenues to underrun 1985 Rate Case projections by about $300 million.

In responding to these challenging conditions, BPA is hampered by a lack of financial flexibility. Over 90 percent of our annual costs are fixed by statute or contract. Our outstanding long-term liabilities total over $14 billion. Approximately 40 percent of our FY 1987 projected revenues will go toward servicing this debt.

We need to respond to these market and financial conditions if BPA is to remain a viable organization and fulfill its statutory responsibilities.

NEW STRATEGIC DIRECTIONS

BPA intends to remain competitive despite conditions of static load growth, commodity-driven price swings, and a high fixed cost ratio. We have acted through an open, "give and take" public process to gain the region's views on program funding and ways we can absorb market shifts and design our rates to mitigate risks of revenue shortfalls. Thus, we have taken steps to cut costs, increase revenues, and improve our financial position.

Regarding cost reductions, before we prepared our FY 1988 Budget and filed our Initial 1987 Rate Proposal, we cut back sharply on spending plans that would have resulted in higher rate increases.

Our search for cost reductions and increased efficiencies has continued since that time. The increase in our priority firm power rate averaged 13.1 percent in the Initial Rate Proposal. Because we found that unacceptable, our internal program managers, as well as external entities such as the Corps of Engineers, the Bureau of Reclamation, the Washington Public Power Supply System, and the Northwest Power Planning Council, have made additional program reductions. Last week, I announced another round of cuts which reduce our FY 1988-89 program levels by nearly $220 million. These levels will allow us to continue to meet all our obligations, including repayment to the U.S. Treasury, and to overcome lowered revenue expectations, at a 9.5 percent rate increase. We believe our proposed rate increase is prudent and necessary, given our obligations. In a moment I will summarize the changes these cuts have made in the budget we propose.

Let me again assure the Committee that our commitment to repay the U.S. Treasury for the Federal investment in the Columbia River power and transmission system remains firm. To ensure that we keep that commitment and protect against substantial deviations from planned cost recovery, certain "risk mitigation measures" are being included in the design of the FY 1988-89 rates. These measures include adequate interest coverage, an automatic rate adjustment provision for the second year of the 2-year period, and revenue assumptions reflecting reduced reliance on export revenues.

We have also acted to increase revenues. We examined all of our major markets for future load, both within the Region and in the Southwest. We are attempting to better understand the needs and to adjust our product and pricing structure to market conditions.

We have valued our long-standing and successful history of mutual energy transactions with California. We are working to extend that success. I have opened my term as Administrator by visiting the Chief Executive Officers of each of the major utilities in California, the State Utility Commission, and key members of the California Congressional delegation. We have affirmed our commitment to mutually beneficial energy transactions and our intent to continue a prosperous relationship between the regions long into the future.

Responding quickly to tumbling prices of oil and gas in California, we adopted new flexible pricing for our economy energy sales, maintaining historic levels of sales to California. Further, we have continued our efforts to conclude new long-term contracts with a number of California utilities. Many of these utilities have power systems which are an ideal complement to BPA, and we expect to be able to achieve long-term marketing relationships. Their eagerness to conclude these arrangements has, of course, been tempered by a current "buyers' market" resulting from widespread Pacific Coast energy surpluses and oil and gas price declines. We remain committed to maximizing the benefits of the Columbia River Power System to both the Pacific Northwest and the Pacific Southwest.

In response to the difficulties experienced by our aluminum customers, we have positioned ourselves to help keep Northwest aluminum companies competitive in the world market. A variable rate, which rises and falls with the market price of aluminum, has been developed and implemented for these customers. Thus, we assure continued demand from this valuable customer sector in a way that benefits both the aluminum companies and BPA's other customers.

We are also turning our energies to aggressive marketing efforts in the Northwest. Our public agency customers are bearing a larger share of BPA's costs because of our losses in other markets. We have made special surplus power offers to these customers for various uses, such as displacement of thermal resources, and have offered price incentives for additional loads that could be brought on line quickly. We are also approaching our customers in load growth areas, primarily privately owned utilities, to determine whether mutually agreeable terms can be found for BPA to supply the power to meet their long-term loads. In short, we are seeking to determine whether the utilities in the region will choose to place load on BPA under new and mutually advantageous conditions.

To guide our overall planning and budgeting during this period of austerity, we have adopted a new perspective on our role as a regional energy provider under the Pacific Northwest Power Act. We have advised our customers of our intent to restrict our load forecasts to include only those long-term loads committed to us by contract.

Thus, we will limit plans to serve the investor-owned utilities' future power needs until the requisite 7-years' notice of need for our power is provided. This may increase the risk that we might eventually need new resources on 7-years' notice, which could potentially lead to higher future costs, but it also allows us to reduce the near-term costs of preparing to serve these loads. This has implications that are not yet fully known for the future of our resource planning, including Supply System Nuclear Projects 1 and 3, currently in deferred construction status. We are already reviewing reductions, beyond those reflected in this budget, that we can make in our conservation resource acquisition programs, particularly home weatherization.

We also plan to continue the development of our organization as we carry out our new strategies. We intend to continue our efforts to increase internal efficiency through employment reductions and functional consolidations, and to curtail overhead expenses.

Finally, we are taking aggressive action to improve our long-term financial performance. We will gradually reduce our fixed cost ratio by constraining our borrowing, follow strategies to eliminate cumulative negative net revenues in our financial statements, and include prudent risk mitigation measures in our rate filings.

REVISED BUDGET LEVELS

In early March we announced lower program spending plans in supplemental rate testimony. A summary of BPA's revised budget projections is attached for your information. These plans call for reducing FY 1988 borrowing from the $205.8 million presented in the President's budget down to $185.2 million in our current proposal. Cutbacks in borrowing have little near-term rate effect, but will reduce fixed costs, debt service, and help improve BPA's financial flexibility in the future.

BPA's FY 1988 expense program obligations have been reduced by $88.6 million from the $2,762.6 million projected earlier in the President's budget to $2,674.0 million.

Finally, the budget carries Capital Transfers of $334.2 million, which represents a slight reduction in interest and amortization compared to the $336.2 million included in the President's Budget in January. The lower amount results from lower estimates of new investments, primarily in the Energy Conservation Program.

Our budget reflects program levels we believe will assure an efficient, reliable, and environmentally acceptable electric power supply for the Northwest. Planned spending is higher than in previous years, due almost exclusively to rising fixed costs. However, the rate of increase in FY 1988 and FY 1989 has been markedly reduced through the cost reductions we have made since June 1986.

CONCLUSION

BPA faces new challenges as it begins its 50th year of service to the Pacific Northwest and the Nation this year. BPA is responding by taking strong action so that we can improve our fiscal condition, satisfy our commitments to the Treasury, assist the Pacific Northwest in its economic recovery, and carry out all of our statutory responsibilities.

This concludes my prepared statement. I will be glad to answer any questions you may have.

DEPARTMENT OF ENERGY
REVISED FY 1988 CONGRESSIONAL BUDGET
BONNEVILLE POWER ADMINISTRATION

BUDGET REDUCTION SUMMARY

	FY 1988 OBLIGATIONS		
	President's Budget	Change	Revised Budget
	($ in millions)		
Capital Program			
Energy Conservation	59.7	-4.1	55.6
System Planning & Construction	123.1	-4.0	119.1
Capital Equipment	9.6	-0.2	9.4
Fish & Wildlife	13.4	-1.7	11.7
Non Program-Specific Reduction	0.0	-10.6	-10.6
Subtotal Capital	205.8	-20.6	185.2
Expense Program			
Expense Programs	2,762.6	-81.2	2,681.4
Non Program-Specific Reductions	0.0	-7.4	-7.4
Subtotal Expense	2,762.6	-88.6	2,674.0
Total Obligations	2,968.4	-109.2	2,859.2
Capital Transfers	336.3	-2.1	334.2
Grand Total	3,304.7	-111.3	3,193.4

CAPITAL PROGRAM REDUCTIONS

Energy Conservation Program (-$4.1 million)

- Possible reduction in the Irrigated Agriculture Program and other program reductions yet to be identified.

System Planning & Construction (-$4.0 million)

- Delay of two area and customer service projects (Salem-Tillamook Reconductoring and Tri-Cities Reinforcement) incurring some additional but reasonable risk to system reliability. Reduction in allowance for funds used during construction (AFUDC), due to lower construction work in progress.

Fish & Wildlife Program (-$1.7 million)

- Reduced funding for Yakima Salmonid Artificial Production Facilities. Will still allow the project to remain on schedule and in conformance with the Council's Fish and Wildlife Program.

Non Program-Specific Reductions and Other (-$10.8 million)

- Management efficiencies in support service contracting and FTE usage to minimize increased revenue requirement in 1987 Rate Filing. These general reductions will be specifically allocated to programs during the start-of-year budget process. One capital software development schedule slipped from 5 to 8 years.

EXPENSE PROGRAM REDUCTIONS

Resource Planning, Acquisition & Oversight Program (-$46.7 million)

- Public Utility tax refund for Hanford Generating Project. Reduced O&M costs and lower or deferred capital addition costs for WNP-2. Sale of fuel assets and lower preservation costs for WNP-3.

- Reduction in load forecasting and other studies, lost opportunity resource acquisitions and hydro options. Reduced wheeling payments.

Residential Exchange Program (-$22.0 million)

- Reduced Gross Exchange cost, as a result of other program reductions which lower the Priority Firm (PF) rate. (The net cost of the Exchange to the ratepayer actually increases as the PF goes down.) Exchange program implementation costs reduced through curtailing support service contracts.

Other Program Reductions (-$12.5 million)

- Reductions in overhead costs for Operating programs, reduced O&M at Corps of Engineers and Bureau of Reclamation hydro facilities, reduced funding for Conservation State Technical Assistance and other support activities, and reduced Transmission RD&D.

Non Program-Specific Reductions (-$7.4 million)

- Management efficiencies in support service contracting and FTE usage to minimize increased revenue requirement in 1987 Rate Filing. These general reductions will be specifically allocated to programs during the start-of-year budget process.

CAPITAL TRANSFER REDUCTIONS

Capital Transfers (-$2.1 million)

- Capital Transfers represent that portion of BPA's Treasury Payments which are not considered to be programmatic obligations, but are considered to be intra-governmental transfers. 1/

- Amortization was reduced slightly to reflect lower levels of new investment (-$2.0 million).

- Interest on appropriated investments was also reduced slightly ($-0.1 million).

1/ Total Treasury Payments include:

	President's Budget	Change	Revised Budget
BPA Bond Interest	152.1	+0.4	152.5
Associated Project Cost	126.7	-1.7	125.0
Capital Transfers	336.3	-2.1	334.2
TOTAL	615.1	-3.4	611.7

Treasury Payments can also be broken down as:

	President's Budget	Change	Revised Budget
Principal	157.5	-2.0	155.5
Interest	359.8	+0.3	360.1
Operation & Maintenance	97.8	-1.7	96.1
TOTAL	615.1	-3.4	611.7

NET OUTLAYS

FY 1988 Net Outlays in the President's Budget will not be increased by these budgetary changes. Net outlays will not be significantly changed because BPA is mandated to recover only its costs in its rates. As a result, lower costs automatically translate into lower receipts.

DEPARTMENT OF ENERGY
REVISED FY 1988 CONGRESSIONAL BUDGET
BONNEVILLE POWER ADMINISTRATION
(dollars in thousands)

LEAD TABLE

	FY 1986 Actual	FY 1987 Estimated Obligations	FY 1988 Base	FY 1988 Request	FY 1988 Revised Request	% Change from FY 1987 Obligations	
						Request	Revised Request
Energy Conserv.	90,583	69,400	69,325	59,700	55,600	-14%	-20%
Sys. Plng. & Constr.	166,017	167,859	167,720	123,100	119,100	-27%	-29%
Capital Equipment	12,506	17,300	17,281	9,600	9,400	-45%	-46%
Fish and Wildlife	8,015	10,200	10,189	13,400	11,700	+31%	+15%
Non-Prgrm. Spec. Red.	0	0	0	0	-10,600		
Subtotal Capital	277,121	264,759	264,515	205,800	185,200	-22%	-31%
Expense Program							
Expense Programs	2,431,567	2,609,600	2,606,798	2,762,600	2,681,400	+6%	+2%
Non-Prgrm. Spec. Red.	0	0	0	0	-7,400		
Subtotal Expense	2,431,567	2,609,600	2,606,798	2,762,600	2,674,000	+6%	+2%
Total Obligations	2,708,688	2,874,359	2,871,313	2,968,400	2,859,200	+3%	-1%
Capital Transfers	356,401	327,300	327,300	336,300	334,200	+3%	+2%
Grand Total	3,065,089	3,201,659	3,198,613	3,304,700	3,193,400	+3%	-1%

Revised 3/9/87

JAMES J. JURA
Administrator
Bonneville Power Administration
U.S. Department of Energy

Biographical Sketch

James J. Jura was sworn in as Bonneville Power Administrator July 18, 1986.

Mr. Jura was born December 9, 1942, in Creston, Nebraska. He first came to the Pacific Northwest in 1962 while serving in the U.S. Army.

After completing his military service, Mr. Jura earned a bachelor of arts degree and was graduated from the University of Washington in 1968. He received a master's degree in business administration from Seattle University in 1970.

Mr. Jura received his master's degree while working for the Boeing Company in Seattle in Boeing's commercial airplane division. Mr. Jura began his Federal career in 1971 with the Department of Labor's Occupational Safety and Health Administration (OSHA) in intergovernmental relations and program planning and evaluation.

He later spent five years with the Office of Management and Budget (OMB) in Washington, D.C. While at OMB, he worked as a Budget Analyst and Legislative Analyst. For a time, he reported directly to the Director of OMB as his Special Assistant.

Mr. Jura was first employed by BPA as the Assistant Manager of its Washington, D.C., office in 1978. He moved to Portland, Oregon, in 1980 to take the position of Executive Assistant Administrator.

Mr. Jura served as a key member of the Administrator's office from 1980 to 1986. As Executive Assistant Administrator, he was responsible for BPA's internal management. He was involved in every major aspect of BPA's activities and was third in line of authority after the Administrator and Deputy Administrator.

Mr. Jura lives in Portland with his wife Frederika and their four children.

REPAYMENT REFORM

Senator HATFIELD. This billion-dollar reduction program, that does not put all of you on a voluntary basis, does it?

Mr. JURA. No, sir.

Senator HATFIELD. Some remuneration is provided. [Laughter.].

I want to commend you, first of all, for the repayment schedule which had stimulated, as you know, a lot of calls within the legislative branch of government, at least, for a reform of repayment schedules.

That also stimulated some, including OMB and the administration, to call for sale of Bonneville and the other PMA's.

I believe that one could say that the repayment policy of the last few years has been part of a reform within the structure of Bonneville. First of all, if that is true, would you highlight some of those changes or reforms? The heart of the question that I would like to put to you is: With these changes and these policy changes that you have made, will the system stay reformed?

I am trying to find a base here to fend off continuing calls within the legislative branch for repayment reforms, because I think Bonneville does represent at least one of the PMA's that does not really need legislative reform. That is my thesis, and I hope you can confirm it.

REPAYMENT COMMITMENT

Mr. JURA. ,Yes, sir; I am here to say that there is a strong commitment in our region and within the Bonneville organization to continue to make these Treasury payments in full and on time. I emphasize that this commitment is within the region, because I think that is a significant achievement that our region has accomplished in recent years.

As I have gone around and talked with our utility customers about this very important issue, I have found no one that is backing away from that commitment, and, in fact, I have found a very, very strong customer commitment and pressure on Bonneville, which we gladly accept, to accept the responsibility of making timely payments and then assuring they are made.

Senator HATFIELD. Do I understand you to say that this recent pattern of repayment schedules represents almost half of the total repayments that have been made since the inception of Bonneville?

Mr. JURA. Yes, sir; in that 5-year period we have paid the amount I mentioned earlier. We have, I believe, had some significant changes of direction in recent years, and that includes not only a thorough understanding and commitment within the region for us to make those payments; but also the fact that Bonneville is conducting its financial affairs to assure that we are positioned each year to make that year's payment.

We are doing that in a number of ways, including managing our costs in a way so that we can respond to these requirements, cash control, and the way we plan our financial obligations for the future. All are done to achieve that objective.

Senator HATFIELD. Mr. Jura, in light of this situation with the world price of oil and the lessening of the demand in the southwestern part of the country, could you highlight a few steps you have taken to try to maintain a competitive role in that market or to respond to the allegations that there is an unfair price gouge that has been proposed by Bonneville, either in the past or in the future.

Mr. JURA. Let me say, that the market condition you mention was a situation that we found ourselves in starting, really, in January of last year. About that time, oil prices started to decline rapidly. As oil prices declined, gas prices followed, and we soon found ourselves priced out of the market in California, where we sell large amounts of surplus energy.

We moved quickly to react to the declining market by proposing to FERC a nonfirm rate that would allow us to price our product to be competitive with other electric energy sources. We received that approval in a very fast action by FERC and went back into that market and have been pricing our product since that time below the other alternatives.

Senator HATFIELD. What is that price level now?

Mr. JURA. Well, at the moment, we are not in that market because of our water condition, but until mid-January, while we were still in the market, it was in the neighborhood of 12 to 14 mills.

Senator HATFIELD. Twelve to fourteen mills?

Mr. JURA. Yes, sir.

Senator HATFIELD. What was the previous high price?

Mr. JURA. It was in the low twenties; on nonfirm. Our FERC approved fully allocated cost based rate for nonfirm power is 22.2 mills per kilowatt-hour.

Senator HATFIELD. So you made a significant reduction in order to try to be competitive?

Mr. JURA. Yes, sir; it has been necessary to bring the price of our product down.

Senator HATFIELD. Does that mean that the previous 20 mills was a gouging of that market, as some have accused Bonneville?

Mr. JURA. No; I don't believe that was the case. That was our FERC-approved cost based nonfirm rate.

Senator HATFIELD. The market bore it?

Mr. JURA. Well, yes; the market bore it until oil and gas prices fell and we lowered our nonfirm rate. We have maintained the practice of not going up to the full market price for nonfirm energy when oil and gas prices were high. We have committed to California in our current rate proposal that we are wiling to put a cost-based lid on our nonfirm prices so our Southwest customers can have some certainty that we won't raise prices up to what the market might bear.

Senator HATFIELD. For what period of time is that commitment or that arrangement?

Mr. JURA. This would be for fiscal years 1988 and 1989.

Senator HATFIELD. And 1989.

Mr. JURA. We recognize that they, as they plan their power and resource projections, need some certainty that we would have some acceptable limits.

Senator HATFIELD. These current negotiations include both firm and interruptible power?

Mr. JURA. This is nonfirm.

Senator HATFIELD. Nonfirm?

Mr. JURA. Yes, sir.

Senator HATFIELD. Are you doing any negotiations with firm power?

Mr. JURA. Yes; we are.

Senator HATFIELD. With California utilities?

Mr. JURA. Yes, we are.

SOUTHWESTERN INTERTIE ACCESS

Senator HATFIELD. Tell me a little bit about that, with whom you are negotiating. Do these have access to the intertie?

Mr. JURA. That is correct.

Senator HATFIELD. Are there utilities that don't have access?

Mr. JURA. Yes; let me run through that quickly. We are focusing our efforts on major utilities and focusing our efforts on those who have access to the intertie. Utilities we have been negotiating with include: Southern California Edison; Los Angeles Water & Power; San Diego Gas & Electric; Pacific Gas & Electric; the cities of Burbank, Glendale, and Pasadena; the city of Santa Clara; the Sacramento Municipal Utility District, and the Western Area Power Administration.

I might mention that in the Southwest, there are four utilities that have a large share of the intertie. They have approximately 80 percent of the capacity of that intertie. Their practices have been such that they keep that allocation for themselves. They do not share it among themselves or with others. They keep it to themselves, and as a result, there are a number of utilities that we do not have access to because of those practices.

Senator HATFIELD. Do you expect to get some change in that policy from them?

Mr. JURA. Well, sir, we are working on a number of fronts, and as part of my effort to get closer to the California issue, I have been down meeting with the key people in those companies. I have met in the last month with the chief executive officers of each of those companies and I think there are some things we can do.

WEST COAST ENERGY POOL

We recently joined with a group of west coast utilities to form a Western System Power Pool. In fact, yesterday, we received word that it had been approved by FERC.

We think these types of actions will allow us to bring some solutions to the west coast marketing problem.

Senator HATFIELD. It certainly, then, reduces the pressure on your rate situation, too, doesn't it, by more of these sales that you can negotiate and promote?

Mr. JURA. Yes, sir.

Senator HATFIELD. And these sales of power are mutually beneficial to both the Northwest and the Southwest?

Mr. JURA. They certainly are. The Southwest and the Northwest have a long tradition of entering into transactions that maximize the benefits that those two regions have. We remain committed to making the most out of this efficient system we have in the Northwest for the benefit of both regions.

N-REACTOR

Senator HATFIELD. I am going to come out of left field now at you, and I want to just have your heads up. Let's talk about the N-Reactor at Hanford for just a moment.

Historically, I believe, you have purchased steam-generated power from Hanford?

Mr. JURA. Yes, sir; we have a contract.

Senator HATFIELD. Yes.

Mr. JURA. With the Department of Energy and the Washington Public Power Supply System.

Senator HATFIELD. Would you describe that for the record, please?

Mr. JURA. We have a contract that allows us and requires us to purchase steam from the N-Reactor when it is running. The reactor normally produces power on a schedule which does not depend on power needs, but rather depends on the need for the material that is produced for defense purposes.

As a result, the power from Hanford is a resource that we sell as nonfirm in the markets I was describing earlier.

Senator HATFIELD. Is the power that you purchase there for the region economical?

Mr. JURA. In our situation today, with the surplus I mentioned, it is not as valuable to us because of the surplus and it is not as valuable to us as it has been in the past when prices in the markets in California were higher.

Senator HATFIELD. How much does it cost, do you know offhand?

Mr. JURA. It costs us approximately 18 mills per kilowatt-hour.

Senator HATFIELD. Eighteen mills.

Mr. JURA. Yes, sir; and I mentioned earlier that we had been selling in the California market in the 12- to 14-mill range.

Senator HATFIELD. Fourteen; so you are paying more there in order to sell for less, if you drew a direct line from the source to the buyer in that case.

Mr. JURA. Yes, sir; those are the recent market conditions.

Senator HATFIELD. Can you give us a total cost on that?

Mr. JURA. Yes; I can. We recently addressed this in our rate case, because we need to project what our revenue requirements are and we had calculated, given our estimates of the circumstances in those markets, that it would be a net cost to Bonneville in the neighborhood of around $17 million per year for those 2 years. We have just made the calculation for our rate period fiscal 1988 and 1989.

Senator HATFIELD. In terms of the total power generated for sale by Bonneville, this is really not a very significant amount, is it, the power that you buy from Hanford? Is it a relatively small amount in terms of your total power?

Mr. JURA. Yes; of the total.

Senator HATFIELD. Production?

Mr. JURA. Yes, sir.

N-REACTOR CONTRACT

Senator HATFIELD. How long is that contract, the current contract for purchase of N-Reactor steam?

Mr. JURA. I am not sure when the contract expires.

Senator HATFIELD. Could you supply that for the record?

Mr. JURA. Mr. Chairman, I am informed that the pertinent contracts expire on June 30, 1993.

I would like to say, however, that we are taking steps—and we have asked the Department of Energy to address this, and they have been very cooperative in dealing with this. We have begun discussions within the Department to move Bonneville to a revenue-neutral position when the reactor is operating. We are just now starting discussions within the Department to take that action.

Senator HATFIELD. Are you planning to renegotiate a contract with Hanford?

Mr. JURA. If that is what it takes; yes, sir, and——

Senator HATFIELD. What takes?

Mr. JURA. Well, what I have asked the Department to do—and they have been receptive to this—is to look to the possibility of renegotiating the contract to move Bonneville to a revenue-neutral position.

I have a need to do this by the time we make final decisions on our rates. If I have not managed to do that by then, then I must include in my revenue requirement the net cost to cover that operation. As I said, that is $17 million a year.

Senator HATFIELD. Do you see this having an impact on whether you are less dependent or more dependent upon that source of power?

Mr. JURA. With our power supply situation, given the surplus I mentioned, we really don't have a need for that power for the next 4 to 6 years.

Senator HATFIELD. That was my next question. What is the need in terms of your projected immediate future, near future, 4 to 6 years? You do not see a real need for that?

Mr. JURA. No, sir.

Senator HATFIELD. I think it is very obvious why I am pursuing this line of questioning, because in 1971, and I believe again in 1976, one of the reasons for extending and investing money in the N-Reactor, one of the reasons given was the steam-generated power that it sold to Bonneville.

As we are now facing another decisionmaking time on the future of the Hanford reactor outside of the repository issue. We face the matter of the environmental impact statement; the issue of the safety recommendations, some 130 modifications recommended by two independent commissions, and the cost factors of all of that. I wanted to make sure that we didn't get back into this kind of piggybacking on Bonneville that has been used, as I see it, piggybacking to argue for extending the life of Hanford any longer than necessary.

That is a policy decision we will have to make, but at the same time, I need the information that you can provide me. I am not asking you at this time to endorse our plan to keep the Hanford reactor shut down, that is outside of the BPA.

CONCLUDING REMARKS

We do have some written questions from other members of the committee and some other questions that we will submit to you, Mr. Jura.

You have done a fine job today. I am putting you at A-plus.

Mr. JURA. Thank you very much, Senator.

Senator HATFIELD. Do you have any further comments you'd like to make to the committee?

Mr. JURA. No, sir.

Senator HATFIELD. Did you have sweaty palms during this time? [Laughter.]

It wasn't difficult, was it?

I am very grateful to Chairman Johnston for letting me conduct this hearing. I served with Chairman Johnston for a number of years on this committee as his ranking minority member; and then for 6 years Chairman Johnston was ranking minority member for my chairmanship, so we have a great relationship here on this committee. It really doesn't make much difference who is sitting here in the chair. We follow pretty much the same line of thinking. I am very grateful that he gave me this opportunity to welcome you to your first hearing.

Mr. JURA. Thank you very much.

Senator HATFIELD. This is only a temporary seat that I am occupying today. I don't know; maybe Senator Johnston would take that a different way than I intended. [Laughter.]

Temporary for the day is what I really mean. I don't want to cut my good deal off here.

ADDITIONAL PREPARED QUESTIONS FOR THE RECORD

As I indicated, there are some additional questions prepared by the staff which I will make part of the record. If you would give those your attention.

Mr. JURA. Yes, sir.

[The questions and answers follow:]

QUESTIONS SUBMITTED BY SENATOR HATFIELD

Repayment

Question: As I recall from previous testimony, the last three years Bonneville has repaid to the U.S. Treasury about $650 million per year and you expect a payment of about $600 million this year. Am I correct that these payments fully meet your repayment obligations?

Answer: Bonneville made it's planned repayments to the U.S. Treasury for the last three years, and I fully expect that Bonneville will make its FY 1987 planned payment.

Question: I note from your statement that BPA has made more than $2.2 billion in principal and interest payments to the Treasury over the past five years. That is almost half of the total payments of $4.8 billion since BPA'S inception.

I believe these figures show that BPA's repayment policies have already been "reformed" by BPA's own actions. Would you outline for us some of the steps you as administrator intend to take to make sure BPA's repayment policies stay "reformed"?

Answer: Yes. As you note, we have already taken several actions intended to improve Bonneville's repayment record. Over the past year, we have repeatedly reviewed our planned programs to arrive at a reduced budget proposal which reflects reasonable levels of spending in light of our anticipated revenue position. Last year, we requested and received interim approval to revise Bonneville's nonfirm rate schedule to permit sales to the Southwest at more competitive rates. In addition, we have put into place an innovative variable rate mechanism designed to maintain or improve our revenues from industrial sales.

In the current rate proceeding, we are proposing a three-faceted risk management strategy specifically designed to address repayment risk. First, we are proposing to design rates to achieve a 1.1 net interest coverage ratio to better assure repayment and to improve Bonneville's financial condition. This design would provide $60 million per year additional assurance that Treasury payments will be made. Second, we are using a relatively conservative secondary sales assumption to assure that our firm power rates are adequate. This strategy would provide for $60-$65 million per year in revenue protection. Finally, we are introducing an adjustment clause which would allow us to raise or lower rates in the second year of our two-year rate period in response to first year financial results. If a substantial shortfall is experienced in FY 1988, then the adjustment clause would provide up to approximately $130 million of added revenue in FY 1989. In combination, these measures will provide increased assurance that Bonneville's revenues are adequate to meet its Treasury commitments.

Long-Term Debt

Question: I would like to turn for a moment to BPA's long-term debt and your plans in that regard. BPA has been criticized for its growth in capital debt to the Treasury over the past several years.

It appears that you are prepared to take some fairly strong measures to reduce that debt growth. Would you elaborate briefly on your plans in this area?

Answer: Yes, last June my predecessor, Peter Johnson, and I began taking some very strong measures to reduce BPA's expenditures, including those funded through long term borrowing. Specifically, I am proud to report that back then BPA's managers began to recognize the long-term effects of the continued reduced aluminium, oil and gas prices upon BPA's future rates and program needs, and the implications of increased long-term debt on BPA's financial situation. In response, they significantly reduced their budget requests.

By the time we completed this self examination, with the help of our customers and others within the Pacific Northwest, we have been able to hold our request to a level where BPA's long-term liabilities of over $14 billion, which includes our debt to the Treasury and our obligations to the Washington Public Power Supply System, will grow by only $110 million in FY 1988. The increase in FY 1989 will be even smaller.

The reductions that we took in our borrowing funded programs affected all of BPA's capital programs; Conservation, Construction, Capital Equipment, and Fish and Wildlife. Although we significantly reduced our planned conservation and fish and wildlife capital spending, we still plan to implement most of the program efforts called for by the Pacific Northwest Power Planning Council in their 1986 Energy Plan and by their Fish and Wildlife Program. We are in regular consultations with the Council members and their staff on our spending plans and we carefully consider their needs in the prioritization of our work as we deal with reduced revenues and curtail new investments. With regards to our System Planning and Construction Program, we are continuing with those construction projects which strenghten our ability to sell additional surplus energy to California and assure that the reliability of the Northwest transmission system is maintained.

Intertie Policy

Question: What is the status of your efforts to develop a long-term intertie access policy?

Answer: On October 31, 1986, BPA published a draft proposed Long Term Intertie Access Policy in the FEDERAL REGISTER and requested public comments on the proposal. The proposed policy is accompanied by a draft Environmental Impact Statement titled Intertie Development and Use, which examines the environmental implications of long-term policy alternatives and various proposed increases in Intertie capacity. The comment period on these documents closed January 16, 1987. BPA received over 1,000 pages of substantive comments which we are currently evaluating and incorporating into our analysis and policy where appropriate.

BPA had originally anticipated distribution of a final Intertie Development and Use EIS and final Long Term Intertie Access Policy in July 1987. However, publication of a final EIS and Long Term Intertie Access Policy have been delayed until fall of 1987. This additional time will allow BPA to give the comments the careful attention they deserve.

This change in schedule necessitates that BPA extend the effective period of the Near Term Intertie Access Policy to provide utilities in the Pacific Northwest and California with planning certainty for the upcoming operating year and to ensure that the fish and wildlife provisions of the Near Term Policy do not lapse. Notice was published in the FEDERAL REGISTER on March 27, 1987, extending the Near Term Policy to June 30, 1988, or implementation of the Long Term Policy, whichever occurs first.

WPPSS - Supply System

Question: Although rates now are stabilizing, in previous testimony, you indicated that rates are 600 percent more than in 1979. How much of the increase is attributable to WPPSS? What percent?

Answer: WPPSS costs currently represent about 65 percent of BPA's Federal Base System resource costs. Nearly all of this amount has been added to BPA's cost since 1979. After accounting for other cost increases, such as for conservation, residential exchange, and transmission, the increase in WPPSS costs account for about 50 percent of the increase in the Priority Firm rates since 1979. WPPSS costs are currently allocated to several classes of service, but primarily to the Priority Firm rate. The Priority Firm rate has increased about 500 percent since 1979.

Question: Both WPPSS 1 and WPPSS 3 have been delayed, and you indicate that the possibility of construction restart appears less likely. What conditions have changed to warrant this modified view?

Answer: The probability of construction restart has been reduced slightly due to a reduction in Bonneville's long-term load forecast. More importantly, Bonneville has recently decided that we will only develop resources to meet loads which we are currently contractually committed to meet. Bonneville has no such contractual commitments from the PNW investor-owned utilities (IOU's) past 1993. Absent future IOU load growth placement on Bonneville, the probability of needing WNP-1 and WNP-3 is reduced further.

Question: How much will be spent in FY 1988 compared to FY 1987 on debt service for WPPSS 1 and WPPSS 3?

Answer: The amount BPA spends on debt service for WPPSS 1 and WPPSS 3 is shown on the table that follows:

		BPA FY 1987	BPA FY 1988
WPPSS 1:	Debt Less Investment Income	211.0	211.7
	Cash Carryover from Prior FY	(8.6)	0.0
		$202.4	$211.7
WPPSS 3:	Debt Less Investment Income	$164.0	$163.7
	Cash Carryover from Prior FY	(4.9)	0.0
		$159.1	$163.7

Question: How much is spent for each plant on preservation costs in FY 1987 and FY 1988?

Answer: WPPSS 1 preservation costs will continue to be paid with construction bond fund proceeds and are not included in BPA's budget or rates. WPPSS 3 preservation costs are shown in the table as follows:

	BPA FY 1987	BPA FY 1988
WPPSS 3 70% Share		
Net Billing	17.6	6.1
Funded from Fuel Sale Proceeds	0.0	6.2
WPPSS 3 30% Share*		
Paid by IOU's	8.0	4.5
Fuel Sale Refund to BPA	0.0	(5.8)

*Does not include other costs related to IOU Settlement

Question: Briefly explain the results of the recent review of the potential restart or termination of WPPSS 1 and WPPSS 3?

Answer: In the draft WNP-1 and WNP-3 Study, BPA concluded that continued preservation is economically prudent, and that termination would create a risk that an event of default would be declared on outstanding WNP-1 and WNP-3 bonds. Since the draft, there have been changes which reduce the economic value of the projects. These changes include the decision to only develop resources to meet loads BPA is currently contractually committed to meet, and a reduction in the estimated costs of new coal plants. BPA is still developing its conclusion for the final WNP-1 and WNP-3 Study, the results of which will be released April 10, 1987.

Question: What are you doing to get a declaratory judgment or other determination on problems which might occur in the event of termination of the plants?

Answer: Bonneville is working with the Department of Justice to assess the potential for a declaratory judgment action to clarify certain contractual rights and obligations regarding termination of WNP-1 and WNP-3. A decision on whether to proceed with a declaratory judgment will not be made until the effects of such an action have been carefully studied, the action and possible alternatives have been discussed with the Supply System and BPA's customers, and the benefits of proceeding have been weighed against the costs.

Question: When do you expect to receive this ruling on the potential increased vulnerability of BPA under termination?

Answer: If a judicial ruling is determined to be the best alternative to pursue, then it would probably take 2 to 3 years from the time of filing to receive a final decision including anticipated appeals.

Transmission

Question: What is the status of BPA intertie planning and construction?

Answer: BPA is currently involved in the planning of the California-Oregon Transmission Project/Third AC Intertie and the construction of the DC Terminal Expansion Project.

I will first review the status of the California-Oregon Transmission Project (COTP) or Third AC Intertie. The plan for constructing a new 500-kV transmission line from southern Oregon to California as described in the February 7, 1985, Memorandum of Understanding signed by Interior Department Secretary Hodel is moving forward.

Substantial progress has been made on the environmental and power systems studies work. A draft plan of service has been developed by COTP participants, and a Draft Environmental Impact Statement (EIS) was published in November 1986. A Final COTP EIS is scheduled for release this summer. A Draft Environmental Report on Northwest Reinforcement Actions appears as Volume 2C of the Draft Environmental Impact Statement. Both Northwest and California utilities are participating in the Oregon Review Committee established by the State. BPA is also preparing an EIS on Intertie Development and Use (IDU) which examines impacts of changes in system planning and operating in the Northwest and Southwest resulting from planned intertie additions and policies governing use of the Federal Intertie. The final IDU EIS is scheduled for release by fall 1987. COTP participants will make their decision on participation in the Project after release of the Final IDU and COTP EIS's and the completion of the California Public Utility Commission's project review in the spring of 1988. The projected inservice date for the Project is early 1991.

During 1986, BPA and PP&L negotiated an agreement to cover rights and obligations on the expanded intertie in the Northwest. BPA is currently engaged in similar negotiations with PGE, and has begun negotiating with California parties over the interconnection of the COTP with the PNW transmission system. A preliminary Northwest plan-of-service has been completed. Northwest utilities are continuing to participate in the planning process in California. BPA is keeping an open mind regarding the possibility of providing other Northwest generating utilities a right to use the Third AC Intertie on a subscription basis. There are differences of opinion among Northwest utilities, environmental groups, and fisheries interests regarding the advisability of moving ahead with a subscription proposal. Any such proposal could only move ahead after adequate public notice and comment.

Now for the status of the DC Terminal Expansion Project. Expansion of the existing PNW-PSW direct current (DC) intertie is in progress. This project will add 1,100 MW to the DC Intertie's existing 2,000 MW transfer capacity. BPA and the Los Angeles Department of Water and Power (LADWP) are making additions to their respective terminals at either end of the 846-mile line, with no significant new transmission lines needed. Completion in February 1989 is planned.

BPA prepared an Environmental Assessment (EA) on the Terminal Expansion Project that was issued to the public in February 1985. Comments received on the EA led BPA to conduct further environmental analyses that were presented in a supplemental EA issued July 1986. The supplemental EA analyzed the environmental effects of hydroelectric operations from utilizing the increased capacity. These analyses, including analysis on the potential for increased fish mortality, supported a Finding of No Significant Impact (FONSI), issued in August 1986.

In October 1985, BPA awarded a $52.7 million contract to Brown Boveri Inc. (BBC) for design, construction, and equipment manufacturing. LADWP awarded a similar $55.05 million contract. Both contracts are divided into two phases. Phase I of these contracts, covering system studies and preliminary design, has been completed. Phase II of the Project began August 29, 1986, and includes final design and construction.

Question: What is your view on the economic feasibility of the Third AC Expansion?

Answer: BPA's draft Intertie Development and Use Environmental Impact Statement (IDU-EIS) released for public comment in October 1986 presented BPA's economic analysis of the comprehensive benefits of the COTP/3rd AC project. This analysis showed that there would be substantial comprehensive benefits net of costs if the project were used for long-term firm contractual arrangements along with additional economy energy transactions. For the final IDU-EIS, BPA is reevaluating the economics of the project in view of changes in load forecasts for the Pacific Northwest and California, and revised natural gas price forecasts. Preliminary results, based on these changed forecasts, indicate that the total benefits may be greater than those reported in the draft IDU-EIS.

Question: Will the Third AC line and the DC upgrade together result in Western Grid Reliability problems without a second DC Intertie to Nevada?

Answer: No, the Third AC line and the DC Terminal Expansion Projects are planned individually to meet the Western Systems Coordinating Council Reliability Criteria for system design. These projects do not depend on one another or a second DC line to Nevada to provide adequate system reliability. Comprehensive outage studies are done and reviewed annually by the Western Systems Coordinating Council to insure that each new project is a reliable addition to the system.

Question: What is your position on the need for the Second DC Intertie from the Pacific Northwest to the Southwest? What do the preliminary economic studies indicate as to the feasibility and timing of this line?

Answer: BPA has conducted preliminary assessments of another DC line known as the Inland Intertie. Seasonal diversity between the Pacific Northwest and Desert Southwest regions offers the potential for contractual arrangements that would efficiently operate resources to meet the capacity needs of both regions. Based on present forecasts and resource plans, neither region anticipates the need to add resources until after the year 2000. Thus, the benefits to be derived from the Inland Intertie through seasonal diversity exchanges would not be realized until after the year 2000. It is BPA's view that the Desert Southwest does not offer considerable potential as an economy energy market. However, there may be potential for economy energy transactions with Southern California via the Inland Intertie. The potential benefits of these economy energy transactions diminish with the completion of the existing DC Terminal Expansion and the COTP/3rd AC projects.

Based on BPA's view of the potential benefits of the Inland Intertie, BPA has only a minor (3.375 percent) interest in the project. BPA's primary concern is to maintain our ability to participate in the planning for the Inland Intertie with a view towards any planned interconnection with the BPA transmission system in the Pacific Northwest.

Procurement

Question: In regard to the procurement restrictions on EHV power equipment mentioned in the FY 1987 bill, what has been the impact? In your view are those provisions having much effect on gaining domestic manufacturers access to foreign markets?

Answer: One goal of this legislation is to encourage foreign governments to open their markets to U.S. firms. At this point, I am unable to say whether this goal is being met. I do not have any information on the foreign marketplace. Federal government procurement policy on EHV equipment can only effect a small portion of the domestic market for this equipment. Historically, the Power Marketing Administrations (PMA's) and TVA accounted for roughly 10 percent of the domestic EHV power equipment market. Because the region's electrical loads are not growing,, we are not buying much of that equipment. Consequently, we are now a considerably smaller market share.

I think that the provisions do provide domestic firms a significant advantage in U.S. government procurements, however. The 30 percent differential, together with the 40 percent drop in the dollar, make domestic firms 70 percent better off than they were 2 years ago in competing for BPA contracts. But in our discussions with representatives of the industry, they have indicated that they do not really need help in the domestic markets.

Generally, the Administration opposes any kind of Buy American provisions, as they send a negative signal overseas, and could just as easily lead to retaliation as to negotiation. In the case of EHV power equipment, however, the Administration chose not to oppose the provisions providing they were temporary. FY 1987 is now the second year under Buy American for the PMA's and TVA. We believe that two years is enough assistance. The President's FY 1988 budget proposes that this provision not be extended in FY 1988.

Blue Lake Project

Question: As you know, the Eugene Water and Electric Board obtained a three-year window under the Water Resources Development Act of 1986 (P.L. 99-662) (November 17, 1986), to obtain a license from the Federal Energy Regulatory Commission for "non-Federal development of hydroelectric power at the Blue River Lake project." EWEB is actively pursuing that license with FERC. What continues to concern them, however, is whether if they obtain the FERC license and decide to build hydro facilities, they will have the right to own and market the power from Blue River.

S17 Does BPA pose any legal objection to EWEB's right to own and operate the facility as a non-Federal entity and to market the power therefrom?

Answer: Bonneville has no legal objection to EWEB's development of the Blue River Lake Hydroelectric Project (Blue River Project) and the marketing of the power produced. This position assumes that the project is not authorized for Federal development, that EWEB secures a FERC license, and that EWEB finances and owns the project independent of any Federal agency so that the power produced by the project is non-Federal power. As a condition of obtaining a FERC license, we believe that EWEB would be expected to assume financial responsibility for any damage caused by construction or operation of the project including damage to fish and wildlife; and to provide that design features adequate to prevent any adverse impacts to Columbia River Basin fisheries are incorporated into the project at EWEB's expense.

QUESTIONS SUBMITTED BY SENATOR BURDICK

Western's Purchase and Transmission of Power from North Dakota

Question: It is my understanding that when the Western Area Power Administration came before this committee about six years ago to request appropriations for funds to build the Miles City, Montana DC converter station, that there were long-term arrangements between Western and the Bonneville Power Administration that would allow the transmission of coal fired generation from North Dakota to northern California to satisfy Western's contractual obligations. The Congress agreed to the arrangement and approved the appropriation. Now I am told that the long-term arrangements were never consummated and that the present contract for transmission across the Bonneville system expires in 1990. I am also told that the Bonneville Power Administration is in the process of finalizing their transmission intertie access policy which would give no priority to transmitting North Dakota coal fired generation to northern California. If that is the case, Mr. Jura, these policies may make the $30 million Federal investment at Miles City, Montana worthless. I am also told that Bonneville committed to pay a part of the cost of the large Colstrip transmission lines on behalf of Western and that investment may also become worthless. I would like for the Administrator of Western and then the Administrator of Bonneville to please give me the facts related to my concerns and, hopefully, your assurance that I have been misinformed.

Answer: We in the Western Area Power Administration (Western) and the Basin Electric Power Cooperative (Basin) began negotiations for the sale of power in mid-1981. Basin was projecting system surplus power with the construction of its Antelope Valley Station coal-fired Unit 1 in 1985 and Unit 2 in 1986. Under this agreement, which was signed in April 1982, Basin would provide 185 megawatts of power from Antelope Valley Station at the Miles City, Montana DC Converter Station. Deliveries of power began in 1986 and continue through October 1990. When the contract was being negotiated, Basin's load growth projections indicated that it needed Antelope Valley Station power for its own load after 1990. However, the parties provided for the contract to continue if neither party gave written notice of termination to the other by October 1989. A letter agreement which supplemented the Basin contract was executed in December 1985. It provided for the start of deliveries in January 1986 and the deferral of deliveries from Antelope Valley Station Unit 3.

Antelope Valley Station power is wheeled from the Miles City Converter Station through Montana Power Company's system, onto the Montana Intertie (Colstrip lines) to the eastern grid on Bonneville Power Administration's (Bonneville's) system. Wheeling through Bonneville's system to Western's system at the California-Oregon border is pursuant to a contract between Bonneville and Western which terminates October 31, 1990. Under the terms of that contract, Bonneville has the right to interrupt Antelope Valley Station power deliveries when the exportable contract is in operation. That is, when the amount of Northwest surplus energy available for export exceeds the amount of intertie capability, typically during the spring run-off and during above-normal rainfall periods, Antelope Valley Station power deliveries are curtailed, but Basin still receives a monthly payment for capacity. Under the letter agreement, such payments for capacity will accrue for credit on deliveries of power in 1990, the last year of the contracts.

While the Miles City Converter Station is obviously important for delivery of Antelope Valley Station power to California, the benefits from this facility are not restricted to the Basin-Western power delivery contract. The original justification for this facility, presented to the Congress in early 1981 in the FY 1982 budget request, focused on the system efficiency and reliability benefits of an East-West Intertie in Montana.

The Miles City Converter Station Environmental Evaluation Report, completed in the Spring of 1982, describes the following benefits from that investment. I would like to insert a list of those benefits for the record.

Miles City Converter Station Benefits

1. Mutual assistance between the eastern and western power networks during emergencies.

2. Ability to take advantage of load diversity between the Western and Central Regions

3. Economy energy exchanges.

4. Opportunities for oil conservation by transferring projected excess coal-fired generation from the central region of the United States to the Western United States where oil-fired generation is required to meet firm load obligations.

5. Increased system reliability.

6. Reserve sharing.

7. Restoration of system operating flexibility.

In the late 1960's through the early 1970's attempts were made to operate the eastern and western United States transmission systems as a single synchronized transmission system. These attempts were unsuccessful. Prior to Miles City, there was only one small intertie connecting the transmission grid in the eastern United States to the grid in the western United States.

The Miles City Station has proved to be an excellent tool for balancing energy supplies between the east and west transmission grids by providing transfer capability for short-term energy exchanges and greater diversity benefits. As a result, the overall efficiency of the Federal power system has been improved. In addition, this load/resource balance is achieved without the need for inconvenient system configurations, thereby providing increased system reliability. The Miles City Converter Station also relieved major operating problems in the local area, and can be used to provide mutual assistance during emergencies. These benefits from the Station will continue after 1990, regardless of the status of long-term arrangements for wheeling Basin's power across Bonneville's transmission system.

Intertie Access Policy

Answer: Bonneville believes that the Memorandum of Understanding executed between the Western Area Power Administration (Western) and Bonneville Power Administration (Bonneville) in early 1984 provides sufficient transmission for Western to satisfy its contractual obligations with Basin Electric Power Cooperative. These obligations continue to the end of October, 1990. Bonneville's proposed Long-Term Intertie Access Policy (scheduled to be finalized this fall) grants firm access to Basin Electric power through October 1990.

In 1981, Western began discussing a potential long-term power purchase from Basin Electric Power Cooperative (Basin) in North Dakota to serve Western's loads in northern and central California. Western also began discussions with Bonneville concerning the transmission of such a purchase over Bonneville's transmission system. Given Bonneville's forecasts of deficit conditions in the Pacific Northwest for the foreseeable future, understandings developed between the two Federal agencies that Western would have access to Bonneville's transmission system to effectuate a power purchase from Basin. On April 15, 1982, Western executed a contract with Basin for 185 MW of power. This contract obligated Western to "take or pay" for this power through October, 1990. Thereafter, Western had no obligations to continue the transaction. Western's obligation was also contingent upon access to transmission facilities. Some of these transmission facilities, including those of Bonneville and the Montana Power Company, had yet to be completed.

Soon thereafter, Pacific Northwest electric demand forecasts changed radically. In July, 1982, Bonneville issued its first official forecast showing the availability of surplus firm power from Bonneville. Other Northwest utilities also began to show surpluses. This surplus power needed access over Bonneville's transmission system to Southwest markets. Consequently, Bonneville faced an unexpected situation in which its own financial needs to market its own surplus power to California and the similar needs of other Pacific Northwest utilities began to compete with Western's expectations of long-term access to the Southwest over the limited capacity of Bonneville's Pacific Northwest - Pacific Southwest Intertie facilities.

Nevertheless, Bonneville offered for public comment a proposed long-term memorandum of understanding between the two Federal agencies which would have provided Western with a 20-year transmission right over Bonneville's system and a 20-year sale of surplus Bonneville power. The comments received by Bonneville from Pacific Northwest utilities, public interest groups and government agencies were highly critical of the proposed 20-year transmission commitment to Western. Senator Baucus of Montana, the Washington Utilities & Transportation Commission, the Montana Public Service Commission, the Idaho Public Utilities Commission and the Public Utility Commissioner of Oregon were among those who asked Bonneville to reconsider the transaction. One of the major themes of this criticism was that Bonneville should not commit Pacific Northwest - Pacific Southwest Intertie capacity to a sale of power from North Dakota when that capacity was needed to transmit Northwest surplus to the Southwest. Commenters argued that Western could purchase less expensive power from the Northwest than from Basin, and that Bonneville had no obligation to provide any transmission to Western, particularly given the fact that the Basin-Western transaction was contingent upon access to completed transmission facilities.

Bonneville gave serious consideration to the expectations of Western, the legitimate concerns of the Northwest, as well as to Bonneville's own obligation to market its power and repay the Treasury. Further negotiations ensued with Western towards a revised transaction which would provide some benefits to all concerned. On February 7, 1984, Bonneville released its Decision Record on the transaction with Western. I would like to insert a portion of this for the record.

BPA Decision Record

> Western, a Federal power marketing agency of the United States, purchased power from Basin Electric after seeking such a purchase from utilities in the Pacific Northwest and, at that time, with the understanding that transmission would be made available using the FCRTS [Federal Columbia River Transmission System] to serve its customers in northern California. Under the contract, Western agreed to purchase from Basin Electric a 185 MW share of the Antelope Valley generating resource with some obligation to pay a share of costs even if Western does not take delivery of power. A significant obligation of the United States could be created if Intertie transmission is not provided for this power. We have determined that BPA, as owner and manager of the Intertie should provide Western transmission to cover the 5 year period that Western is obliged to take Basin Electric power. This 5 year period reflects a reduction in both scope and term of earlier drafts of the MOU, and still allows BPA to effectuate a commitment made by the United States Government (through Western) during good faith negotiations between Western and Basin Electric.

This document also contains the following statement:

> BPA has negotiated this MOU with Western to meet both BPA's and Western's near term needs. The MOU reflects a compromise on

> issues by both parties. BPA and Western expect to consider elements of a long term arrangement upon completion of the IAP [Intertie Access Policy], and subject to the IAP, as a follow on phase to the proposed MOU. Such elements may include (1) the arrangements and term of a negotiated agreement for the renewal or replacement of Western's 5 year contract with Basin; (2) the conditions, terms, amount, and transmission rights for Western should it choose to purchase Pacific Northwest non-Federal resources; and (3) the conditions, terms, amount, and transmission rights available to Western for any purchases it may negotiate for BPA power.

Thus, this very difficult issue was resolved by meeting the near-term needs of Western and Basin while also retaining flexibility for Bonneville in the face of the new energy realities in the Pacific Northwest.

Though Western can rely on access to Bonneville's transmission system only until 1990 to wheel Basin power, we do not agree that the Federal investment in the Miles City Converter Station will become worthless. Western's Environmental Evaluation Report on the Miles City Converter Station lists benefits which Mr. Clagett has elaborated.

The Report explains that attempts had been made throughout the 1960's and 1970's to interconnect the eastern and western transmission systems in Montana, South Dakota, Wyoming, Nebraska, and Colorado. These early attempts, which occurred long before the Basin-Western agreement, recognized that many benefits, other than wheeling power to northern California, would accrue from such an interconnection.

We also believe that the investment in the Federal share of the Colstrip transmission lines will not become worthless if Western is unable to wheel Basin power to California after 1990. That share will continue to be available for transactions, such as power exhanges and economy energy sales, between the Northwest and areas to the east.

Question: I understand that under the proposed Bonneville Intertie Access Policy, imported Canadian hydropower would have a priority over domestic generation. If this is true, this raises what I consider serious national energy policy issues especially since there is surplus generating capacity in the United States. Would you please respond, Mr.Jura?

Answer: It is not true that the proposed policy provides a priority for Canadian electricity. Under the proposed policy, for access for economy energy sales when there is more demand in the Pacific Northwest for use of the Intertie than there is Intertie capacity, known as Conditions 1 and 2, access would be limited to BPA and Pacific Northwest utilities. When there is less demand in the Pacific Northwest for use of the Intertie than there is capacity, known as Condition 3, extraregional utilities would be provided access to the excess capacity. Under this condition, consistent with the Ninth Circuit Court of Appeals decision in Los Angeles Department of Water and Power v. Bonneville Power Administration, the proposed policy would provide access to extraregional U.S. utilities before access would be provided for Canadian utilities on an hourly basis. Under the proposed policy, all extraregional utilities, both within and without the United States, would not receive firm contractual access.

However, the draft policy does recognize the close proximity of BC Hydro to the Pacific Northwest in terms of electricity interconnection, the interrelated nature of our generation systems on the Columbia River, and the historical relationship established by treaty between the two countries concerning management of the Columbia River. This close proximity creates the opportunity to realize even greater benefits for BPA and the Pacific Northwest through increased coordinated planning and operation of the Columbia River system. The draft policy offers that increased intertie access for BC Hydro may be appropriate consideration for the operational benefits that BPA and the Pacific Northwest could derive through increased coordinated planning and operations with BC Hydro.

ADDITIONAL STATEMENTS FOR THE RECORD

Senator HATFIELD. The staff has also informed me that the prepared statements of the other PMA's have been submitted for inclusion in the record. So, without objection, those will be made part of the record at this point.

[The statements follow:]

STATEMENT OF DONNA R. FITZPATRICK, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

Mr. Chairman and Members of the Subcommittee, I am pleased to be here with the five power marketing administrators to present their budget requests for FY 1988.

First, let me introduce my colleagues: Robert J. Cross, Administrator of the Alaska Power Administration; Harry Geisinger, Administrator of the Southeastern Power Administration; Ronald H. Wilkerson, Administrator of the Southwestern Power Administration; William H. Clagett, Administrator of the Western Area Power Administration; and James Jura, Administrator of the Bonneville Power Administration. Each of the administrators will speak to the budget needs of his own agency.

The President's FY 1988 budget reproposes divestiture of the five power marketing administrations (PMAs), which supply 6 percent of the electricity generated in this country. We recognize, however, that Section 208 of the Urgent Supplemental Appropriations Act of FY 1986 (P.L. 99-349) forbids us to conduct studies of divestiture of the PMAs located within the lower 48 states in the absence of specific authorizing legislation. The administration continues to believe that divestiture can lead to creation of new enterprises that are more responsive to regional and customer needs, without significant increases in power rates.

The President's FY 1988 budget proposes legislation authorizing a study of divestiture of the Southeastern Power Administration. Also, we are continuing to work on the divestiture of the Alaska Power Administration. The Administration's activities will be coordinated with Congress and with existing power customers, and legislative authorizations will be sought prior to implementation. The budget assumes that divestiture of the Southeastern and Alaska Power Administrations will be authorized and implemented by the end of 1989.

The President's FY 1988 budget also proposes legislation which will modify the repayment practices of the five PMAs. As long as the PMAs remain under Federal ownership and control, it is highly appropriate that they repay the federally financed investment on a regular, business-like basis. To assure regular repayment, our proposal will call for the PMA's to repay the Federal investments in a fixed, straight-line amortization schedule. The proposal would not increase the PMAs interest costs or the total Federal investment to be repaid, but merely would ensure that annual repayments occur on a predictable and stable schedule. While this initiative will not affect the level of Federal funding in support of the PMAs, it will permit more rapid repayment of the Federal investment and thus serve to reduce the Federal deficit.

Mr. Chairman, that completes my testimony. The power marketing administrators have statements on their budget requests and we will be glad to answer any questions you may have.

BIOGRAPHICAL SKETCH

DONNA R. FITZPATRICK

Donna R. Fitzpatrick was nominated by President Reagan on July 31, 1985, and confirmed by the Senate on December 19, 1985. She was sworn in as Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy (DOE) on December 20, 1985. She had served as Acting Assistant Secretary since March 11, 1985, and as the Principal Deputy Assistant Secretary since January 1984.

In this position her responsibilities include management of research and development programs in energy efficiency and alternative fuels for industry, buildings, and vehicles. The programs in renewable energy resources involve research in active and passive solar, photovoltaic, wind, ocean thermal, geothermal, and biomass technologies. In addition, she administers federal grant programs for low-income home weatherization and energy efficiency improvements in schools and hospitals, and coordinates management of three of the five federal power marketing administrations.

In 1983, Miss Fitzpatrick served on a consultant team for the Secretary of Energy to conduct a general review of the Department's conservation and renewable energy programs, focusing on policy, program goals and priorities, budget levels, and new initiatives. In 1980, she served the Office of the President-elect as a member of the Transition Team for the National Science Foundation, reviewing national policy in basic science research, project efficiency, funding, and proposed legislation.

In her law practice, first with the Washington, D.C., firm of O'Connor and Hannan and then as a sole practitioner, Miss Fitzpatrick worked extensively on real estate development, helping to coordinate public and private interests and activities where Federal and District of Columbia involvement was required. This included work with local utilities and engineering planners to determine the legal, economic, and technical feasibility of various energy options,, such as solar, cogeneration, and an on-site power generation and district heating system for large scale, high density residential and commercial uses.

Miss Fitzpatrick is also experienced in civil litigation, including administrative law and contracting issues.

Miss Fitzpatrick received a Bachelor's degree in physics cum laude from the American University in 1972. After teaching high school chemistry and mathematics, she entered law school and graduated from the National Law Center of George Washington University in 1980.

January 1986

ALASKA POWER ADMINISTRATION

STATEMENT OF ROBERT J. CROSS, ADMINISTRATOR

Mr. Chairman and Members of the Committee:

The Alaska Power Administration is proposing an FY 1988 budget of $3,191,000, to be funded with $3,026,000 in new appropriations and $165,000 in deferrals from FY 1986. This would provide adequate funding to continue our reponsibilities for the Eklutna and Snettisham Hydroelectric Projects.

We are proceeding with work towards sale of the Alaskan projects. The budget assumes that the sale can be completed by the end of FY 1989.

APA PROGRAMS

APA operates the two Federal hydroelectric projects in Alaska. These are the 30 MW Eklutna Project which provides about 5 percent of the power for Anchorage and the Matanuska Valley, and the 47 MW Snettisham Project which is the main power supply for Juneau. A 31 MW expansion of Snettisham -- the Crater Lake Unit -- is under construction by the Corps of Engineers with power projection expected to begin in the Fall of 1988.

The APA responsibilities include operations, maintenance, transmission, and marketing in accordance with the authorizing legislation for each Project. Our objectives include maximizing energy production over the long term, assuring adequate levels of maintenance, and meeting repayment requirements.

Both Projects were authorized and built as single purpose power developments with costs to be recovered from power revenues. Balances to be repaid as of the end of FY 1986 were $16.6 million for Eklutna and $96.7 million for Snettisham. This does not include the new Crater Lake Unit for which construction costs will be about $50 million.

Both Projects are in good condition, reflecting adequate levels of funding over the years for O&M activities, including funding for needed replacements and improvements.

Significant non-power uses have developed at each Project through a combination of State, private, and municipal investments. These include salmon hatcheries at each project and State recreation management at Eklutna. Construction continues on Anchorage's Eklutna Water Project, which will provide the main water supply source for Anchorage on a long-term basis. The new municipal water project should be operational in early 1989.

FY 1986 AND 1987 ACTIVITIES

We are pleased to report successful and essentially trouble-free operations since last year's hearing as well as satisfactory progress on the maintenance objectives.

We have a substantial program underway on automation of the Eklutna powerplant which we expect to complete by the end of FY 1987. This will allow us to shift to remote operation by supervisory control with a net savings of 3 permanent positions. As reported last year, we will contract with one of our customer utilities to handle the remote operations using net-billing arrangements. Similar arrangements have been in place at Snettisham for the last 3 years.

Other significant items include continuation of line maintenance programs, procurement of a replacement turbine runner at Eklutna which is now being fabricated, and replacement of PCB transformers at each Project.

APA reported gross revenues of $7,372,000 in FY 1986 with energy sales of 324 million kilowatt hours. Estimates for FY 1987 are $8,469,000 in revenues with sales of 349 million kilowatt hours. Satisfactory repayment progress at each project is expected to continue.

Favorable cost experiences in FY 1986 resulted in the proposed $165,000 deferral which would partially finance the FY 1988 programs. The full amount of our $200,000 emergency fund remains available.

FY 1988 BUDGET

The FY 1988 program level request of $3,191,000 is slightly below the levels provided in FY 1986 and FY 1987.

The request is quite routine. It provides for continuing the normal operations, maintenance, marketing, and administrative management programs.

The request provides for continuing the intensive line maintenance program at Snettisham and for several one-time but relatively small maintenance activities. It also provides $385,000 in needed equipment purchases and vehicle replacements.

The FY 1988 staffing level of 35 FTE reflects the shift to fully automated operations at Eklutna.

The requested funding will assure continuation of the excellent service record of the two APA projects.

REPAYMENT REFORM

This budget proposes Power Marketing rate reform legislation and assumes enactment and implementation by the end of FY 1989. These modifications would require repayment of the unpaid balance of the original Federal investment at a level not less than would be required under a fixed, straight-line amortization schedule for each power investment financed by appropriations and placed in service.

DIVESTITURE ACTIVITIES

Work towards sale of the APA projects has continued as outlined in our testimony last year. Our joint report with the State on sale issues was completed last April. In July, we published our preliminary work plan and review of alternative structures. We contracted with a consultant to prepare an independent asset valuation and further review of sale structures. With the benefit of public comments and the consultant's reports, we published a revised work plan and proposed sale structures in January 1987.

Our current plan calls for an April 1 invitation for purchase proposals from our utility customers, municipalities in the areas served, and the State, or a combination of these entities. The proposals would be received by August 1. We expect to complete by early 1988 the necessary steps to present specific proposals for Congressional consideration.

Concern about potential rate increases has been evident throughout our work on the sale plans. We are suggesting minimum payment terms keyed to present value of the interest and principal payments the Treasury would receive under continued Federal ownership. We believe such terms will keep the Treasury whole and allow a purchaser to obtain financing without unacceptable rate increases.

The divestiture work has proven to be more time-consuming than I had anticipated a year ago or two years ago. However, we have made good progress. The sale idea remains sensible. We believe we will have specific, fair, and workable proposals early next year for Congressional consideration.

I would be happy to answer questions and provide additonal data to your Committee as needed.

Thank you.

BIOGRAPHICAL SKETCH OF ROBERT J. CROSS

Mr. Cross was appointed Administrator of the Alaska Power Administration in June 1976. He has been on the Alaska Power Administration (APA) staff since the agency was formed in 1967. He was a staff engineer in the APA Planning Division between 1967 and 1973, and Planning Division Chief from 1973 to 1976.

Mr. Cross entered Federal Service in 1956 as a hydraulic engineer with the Bureau of Reclamation. Between 1956 and 1967, he had planning assignments with Reclamation in Colorado, Wyoming, Nebraska, and Alaska with a 2-year break for active service in the U. S. Army.

Mr. Cross is 53, and a native of Lincoln, Nebraska. He attended public schools in the states of Nebraska, Washington, and New York, and is a Civil Engineering graduate from the University of Colorado. Cross has been a resident of Juneau, Alaska, since October 1964.

SOUTHEASTERN POWER ADMINISTRATION

STATEMENT OF HARRY C. GEISINGER, ADMINISTRATOR

Mr. Chairman and Members of the Committee:

It is a pleasure to appear before you today to present the FY 1988 budget request for the Southeastern Power Administration. I will summarize the major program areas of the request and discuss some of our accomplishments.

The Southeastern Power Administration, with headquarters in Elberton, Georgia, markets hydroelectric power from projects constructed and operated by the U.S. Army Corps of Engineers located in 10 southeastern states. Southeastern has no transmission lines and accomplishes the delivery of power by wheeling agreements with power utilities in the area that have the necessary transmission facilities.

Southeastern presently markets power from 22 multiple-purpose projects to 291 power purchasers. Estimated power revenues for FY 1988 are $136.6 million, reflecting the sale of 3,092 megawatts of installed capacity with 7.4 billion kilowatt-hours of energy.

Southeastern's overall repayment status is as follows: from inception in 1950 to September 30, 1986, operating revenues available for repayment totaled $1,340,547,000. These revenues were allocated to payment of $555,470,000 of annual operating expenses, $479,086,000 of interest expense, and $305,991,000 of capital investment in electric plant. The total capital plant on September 30, 1986, of $1,397,907,000, less the amount repaid, leaves a balance of $1,091,916,000 to be repaid.

FY 1988 BUDGET

A funding level of $27,400,000 is requested in the President's 1988 Budget to effectively carry out Southeastern's mission. The FY 1988 program level request represents an increase of $5,664,000 over the amount authorized for the current year.

A comparison by activities of the FY 1988 Operations and Maintenance budget request with the amounts available in FY 1987 is as follows:

	FY 1987	FY 1988	Difference
System Operation and Maintenance	$ 2,031,000	$ 2,104,000	$ +73,000
Purchase Power and Wheeling Charges	19,705,000	25,296,000	+5,591,000
Total Program Level	21,736,000	27,400,000	+5,664,000
Deferral Applied	-2,089,000	0	
New Budget Authority	$19,647,000	$27,400,000	

SYSTEM OPERATION AND MAINTENANCE

The request of $2,104,000 for the System Operation and Maintenance activity will provide funds for the negotiation and administration of wheeling and power sales contracts; development and review of rates to assure repayment of power costs; scheduling the generation of power and supervision of power deliveries; and direction and support of Southeastern's power marketing program. This amount represents a $73,000 increase over the amount available in the current year.

The major portion of the request for this activity provides funding for personnel compensation and related costs and reflects the continuation of the current manpower level of 40 full-time equivalents. The request provides for increases resulting primarily from statutory within-grade and Performance Management Recognition System increases, terminal leave payments, additional personnel benefit costs, and higher administrative costs for support functions.

No increase in the manpower level of 40 full-time equivalents is requested for FY 1988, although significant workload increases are occurring. As a result of changes in the marketing program, Southeastern is serving significantly more customers within enlarged marketing areas under different marketing conditions, affecting workload throughout the agency. Southeastern plans to accomplish these workload increases within the current manpower level through improved management of employee resources and additional use of automation.

PURCHASE POWER AND WHEELING

The major portion of the budget request, $25,296,000, is required for the Purchase Power and Wheeling activity and represents an increase of $5,591,000 over the amount available in the current year.

Funds provided for this activity are used to pay amounts charged the Government under contractual arrangements for (1) delivery of power over non-Federal systems to load centers of preference customers for the account of the Government, (2) purchase by the Government of energy, if necessary, during adverse water periods, and (3) support capacity required to meet commitments for the Jim Woodruff Project under adverse water conditions.

In the absence of ownership or operation of transmission facilities, Southeastern carries out its marketing program by utilizing the existing transmission systems of the power utilities within its marketing area. This is accomplished through wheeling arrangements between Southeastern and each of the area utilities that have transmission lines connected to the projects, under which the utility agrees to deliver specified amounts of Federal power to customers of the Government and Southeastern agrees to compensate the utility for transmission service performed.

Southeastern has been deeply involved in the development and implementation of new power marketing policies for its respective systems which will ultimately allow all available Southeastern power, both capacity and energy, to be marketed to preference customers. These new policies have been implemented as new contracts were executed for the respective marketing areas.

Contracts providing for the sale of all power to both existing and new preference customers which are expected to be in effect during FY 1988 cover the following Southeastern sales:

1. that portion of the power produced in the Georgia-Alabama System which is marketed within the service areas of South Carolina Public Service

Authority, South Carolina Electric and Gas Company, and Duke Power Company.

2. that portion of the power produced in the Cumberland System which is wheeled outside the TVA service area as well as that portion to be sold within the TVA service area.

3. all power produced in the Kerr-Philpott System to be marketed in the Appalachian Power Company, Virginia Power, and Carolina Power and Light Company service areas.

4. that portion of the power produced in the Cumberland System and designated to be marketed in the service areas of Carolina Power and Light Company (Western Division), and Kentucky Utilities.

With respect to that portion of the power produced in the Georgia-Alabama System and sold in the Southern Company service area (Georgia, Alabama, Mississippi, and the panhandle of Florida), wheeling charges will be handled, to the extent possible, by net billing with the affected utilities during this period. Decreasing quantities of capacity will be sold to the utilities through May 1991, and charges to the utilities for this capacity will be used to offset charges by the utilities for transmission services provided. During FY 1988, increased funding will be required for payment of transmission services under contractual arrangements with Georgia Power Company, since capacity sales to the company will be insufficient to fully net bill the charges for transmission services provided by the Company.

Additionally, purchase power and wheeling funds are required under the provisions of existing contracts for the sale of power produced at the Jim Woodruff project and now sold in the Florida Power Corporation service area.

STUDY OF DIVESTITURE OF SEPA

Legislation will be proposed that would allow the Department of Energy to study the possible divestiture of the Southeastern Power Administration and would also allow other executive branch agencies to review the results of the study. The objectives of the proposed study would be to assess the feasibility of divestiture of SEPA including the identification and analysis of divestiture alternatives that are responsive to regional and customer needs, without causing significant increases in power rates. In undertaking the proposed study if authorized by Congress, the DOE will consult with all interested parties, including SEPA's existing power customers, or their designated representatives, and the Tennessee Valley Authority (TVA), concerning SEPA's four systems of projects. The Department will identify potential customer and regional impacts, as well as possible impacts on TVA, as part of the consultation and study process. The results of any such study will be reported to the Congress and no implementation of divestiture will begin without subsequent Congressional authorizations. Should Congress allow the proposed study, it would be our intent to fund it from Departmental Administration appropriations. Its cost should not be charged to SEPA's customers.

REPAYMENT REFORM

This budget proposes Power Marketing rate reform legislation and assumes enactment and implementation by the end of FY 1989. These modifications would require repayment of the unpaid balance of the original Federal investment at a level not less than would be required under a fixed, straight-line amortization schedule for each power investment financed by appropriations and placed in service.

POWER SYSTEMS

Southeastern's projects are grouped for marketing purposes into four financially independent systems. The power systems, customer locations, and status of wholesale rate adjustments are hereinafter discussed. Southeastern has accomplished all of its recent rate adjustments with a minimum of difficulty.

GEORGIA-ALABAMA SYSTEM

The Georgia-Alabama System is comprised of the Allatoona, Buford, Carters, Clarks Hill, Walter F. George, Hartwell, Robert F. Henry (formerly Jones Bluff), Millers Ferry, Richard B. Russell, and West Point projects. Two of the four units at Carters are pump-generator units. Power from the system is sold to customers located in Georgia, Alabama, North and South Carolina, Mississippi, and Florida. Power rates for this system, applicable [illegible]

October 1, 1985, through September 30, 1990, were approved by the Federal Energy Regulatory Commission on July 22, 1986.

The four pump-generator units at the Richard B. Russell Project, which will provide an additional nameplate capacity of 300,000 kw, are scheduled to begin operation during 1990.

CUMBERLAND SYSTEM

The Cumberland System includes the Wolf Creek, Center Hill, Dale Hollow, Old Hickory, Cheatham, Barkley, J. Percy Priest, Cordell Hull and Laurel projects. The projects are located on the Cumberland River or its tributaries, and are located in northern Tennessee and southern Kentucky.

System power is marketed to customers located in Tennessee and in portions of Mississippi, Kentucky, Illinois, and North Carolina. Power rates, applicable from July 1, 1984, through June 30, 1989, were approved by the Federal Energy Regulatory Commission on a final basis on December 27, 1984. On January 20, 1987, the Commission approved an amended rate schedule for the customers located in the western service area of the Carolina Power and Light Company for the period September 1, 1986, through June 30, 1989.

KERR-PHILPOTT SYSTEM

Power from the John H. Kerr and Philpott projects, located in the Roanoke River Basin in Virginia, is marketed to customers in Virginia and North Carolina. Power rates for this system, applicable from October 1, 1986, through September 30, 1991, were approved on a final basis by the Federal Energy Regulatory Commission on January 23, 1987.

JIM WOODRUFF SYSTEM

The Jim Woodruff Project is located on the Apalachicola River on the Georgia-Florida state line. All dependable capacity available at the Project is sold to preferred customers in peninsular Florida. Revised power rates for the Jim Woodruff Project were approved by the Federal Energy Regulatory Commission on January 10, 1983, for the period ending August 19, 1987.

DROUGHT CONDITIONS AND ENERGY PURCHASES

During 1986, project energy generation was significantly below expected average generation in all systems as rainfall deficiencies surpassed historical records at many locations throughout the Southeast. While all systems were impacted by the drought, the 10-project Georgia-Alabama System was especially hard hit. In June, Southeastern began purchasing replacement energy for a portion of the contract energy from area utilities, thus reducing project generation and at the same time protecting the system dependable capacity. Purchases of replacement energy were suspended in November, following improvement in the overall energy-in-storage condition of the reservoirs.

Southeastern purchased a total of 384,700 mwh at a cost of $9.7 million, requiring use of the Southeastern Continuing Fund. In the absence of such purchases of replacement energy, Southeastern would have defaulted on 176 preference customer contracts in the Georgia-Alabama System. Purchases of replacement energy did not become necessary in the other systems.

Recent rains have provided significant improvement in all systems with all projects in good condition with respect to water levels for this time of the year, with the exception of the Buford Project. The Buford reservoir (Lake Lanier) remains below its rule curve. In view of recent rainfall and current forcasts, it appears that all reservoirs should recover.

POWER MARKETING POLICY FORMULATION

Southeastern has been deeply involved in the formulation, with broad public participation, of new written power marketing policies for its several systems, to replace previous ad hoc approaches to power marketing. Major issues requiring attention include marketing area, allocations of power, handling of pumped-storage energy, utilization of area utility systems, wholesale and resale rates, and conservation measures. The major goal of each policy is to market all available power to preference agencies.

Southeastern has published final marketing policies for its ten-project Georgia-Alabama System, its nine-project Cumberland System, and its two-project Kerr-Philpott System. Policy action with respect to the Jim Woodruff System is not anticipated in the near future since all dependable capacity and energy is presently being sold to preference customers. All Southeastern power marketing policies contain guidelines, including proposed marketing areas and allocation formulas, for marketing the available power for approximately the next ten years.

POWER MARKETING POLICY IMPLEMENTATION

Long-term contractual arrangements implementing the Cumberland System Power Marketing Policy have been negotiated and placed into effect with the Tennessee Valley Authority (TVA), benefiting 160 preference customers within the TVA service area, and with preference customers in portions of Mississippi, Kentucky, and Illinois. Contractual arrangements have also been negotiated and placed into effect with Carolina Power and Light Company (Western Division) and three preference agencies within the Company's service area.

The Cumberland Policy also provides for the sale of Cumberland power to public bodies and cooperatives located in the Kentucky Utilities Company service area. Service to these preference customers will be delayed pending development of wheeling contracts with the utility system. Southeastern plans to move expeditiously to complete the marketing program in this area as soon as possible.

New long-term arrangements have been placed in operation for the western portion of the Georgia-Alabama System implementing the Georgia-Alabama System Power Marketing Policy. Contracts have been executed with the operating utilities of the Sourthern Company (Georgia, Alabama, Mississippi, and Gulf Power Companies) and preference customers in their service areas. Under these arrangements, the conversion to the policy of ultimately marketing all power to preference customers will be phased in over a seven-year period. Negotiations have been completed and contracts executed with South Carolina Public Service Authority, Duke Power Company, South Carolina Electric and Gas Company, and preference agencies within their service areas covering the marketing of power produced in the Georgia-Alabama System and Sold in the eastern portion of that System. These negotiations added 26 new preference customers.

Negotiations have been completed with Virginia Power Company, Carolina Power and Light Company, and preference entities within their service areas to implement the Kerr-Philpott Power Marketing Policy. These negotiations added 41 new preference customers. Negotiations are currently in progress with Appalachian Power Company and preference customers within the Company's service area. These negotiations are expected to add 6 new preference customers.

LITIGATION

This month Southeastern Power Administration expects to bring to a close over four and one-half years of litigation with ElectriCities of North Carolina, Inc., involving its marketing policies. Implementation of its final Kerr-Philpott marketing policy will be completed by execution of contracts with Virginia Power Company, Carolina Power and Light Company and preference customers in those service areas, and a dismissal of the ElectricCities II litigation requiring such implementation will be sought from the United States District Court in Raleigh.

This concludes my statement, Mr. Chairman, and I would be happy to answer any questions that you may have.

BIOGRAPHICAL SKETCH

HARRY C. GEISINGER

Harry C. Geisinger became the fifth Administrator of the Southeastern Power Administration in November 1981, having been appointed to that post by the Secretary of Energy. He is responsible for directing all programs of a federal regional power authority, including power marketing, operation, maintenance, and administrative management. Southeastern transmits and disposes of surplus electric power generated at Federal reservoir projects in ten Southeastern states. The Administration sets the lowest possible rates to consumers, consistent with sound business practices. His responsibilities also include the negotiation, preparation, execution and administration of contracts for the disposition of electric power to all classes of utilities.

Mr. Geisinger also serves as a member of the Executive Board of the Southeastern Electric Reliability Council, a member of the Executive Committee of the Virginia-Carolinas Reliability Council (VACAR), and as Chairman of the VACAR Advisory Committee for the "Region Specific Study of Methods of Strengthening the U. S. Electric Utility Industry" coordinated by the Southern States Energy Board.

He served as a member of the Georgia House of Representatives for three consecutive terms, 1968 to 1974, and was the Republican candidate for Governor in 1974.

He has participated in community activities, including the Doraville Jaycees; Atlanta Boy Scout Council; served as President and Chairman of the Board of the DeKalb County American Cancer Society from 1972 to 1974; Chairman of the Board of the Georgia State Soccer Association and President of the Georgia Youth Soccer Association 1979-1980.

SOUTHWESTERN POWER ADMINISTRATION

STATEMENT OF RONALD H. WILKERSON, ADMINISTRATOR

Mr. Chairman and Members of the Committee:

It is a pleasure to present the Southwestern Power Administration's (SWPA's) Budget request for Fiscal Year 1988. A few summary statistics provide a broad outline of SWPA's request.

	Adjusted FY 1987*	FY 1988	Difference
Total Budget	$38,560,000	$36,654,000	$-1,906,000
Reimbursable Authority		-6,346,000	-6,346,000
	$38,560,000	$30,308,000	$-8,252,000
Available Prior Year Balances	-13,243,000	-13,660,000	-417,000
Appropriations	$25,317,000	$16,648,000	$-8,669,000

*FY 1987 appropriations were administratively reduced by $20,000 in the area of public relations and foreign travel.

The proposed total budget shows an overall reduction of $1,906,000 or five percent. The need for new appropriations has been reduced by $8,669,000 or 34 percent. This significant reduction in appropriations was achieved through the overall reduction of requirements by $1,906,000, the elimination of the need for duplicate appropriations by Southwestern Power Administration and other Government agencies of $4,625,000, the use of non-Federal funds of $1,721,000, and carryover of prior year funds of $13,660,000. The SWPA service area experienced the third straight year of generous rainfall in FY 1986, which was effectively utilized to significantly reduce the need for power purchases. SWPA's FY 1988 appropriation request will continue an efficient and effective program.

MISSION

Southwestern Power Administration (headquartered in Tulsa, Oklahoma) markets hydroelectric power generated at Federal dams, at lowest possible rates, consistent with sound business principles, giving preference in the sale to public bodies and cooperatives. SWPA schedules the operation of the Corps of Engineers' generating facilities for optimum resource utilization. SWPA designs, constructs, and operates its transmission facilities in a safe, reliable manner, consistent with good utility practice. SWPA facilitates the development of environmentally clean, renewable resources and energy conservation practices. In carrying out its mission, SWPA manages in an open manner with customers, employees, the Department of Energy, the Congress, and the general public.

STAFFING

The requested FY 1988 staffing level is 186 FTE positions, the same as FY 1987.

FY 1988 BUDGET INFORMATION

SWPA's budget is subdivided into three general activities: (1) Purchase Power and Wheeling, (2) Operation and Maintenance, and (3) Construction.

	Adjusted FY 1987	FY 1988	Change
Purchase Power and Wheeling	$20,959,000	$15,813,000	$-5,146,000
Operations and Maintenance	11,782,000	13,132,000	+1,350,000
Construction	5,819,000	7,709,000	+1,890,000
Total Budget	$38,560,000	$36,654,000	$-1,906,000

I will summarize the major factors which make up these figures in each of these activities.

(1) Purchase Power and Wheeling

This activity provides for the funding of energy purchases necessary to meet the Government's commitments to utility customers' sales contracts when low water conditions occur. The proposed $15,813,000 budget for purchase power and wheeling costs is a reduction from FY 1987 of $5,146,000, due to SWPA's continuing conversion of high-energy contracts to 1200-hour per year peaking-power contracts. The budget amount includes $11,188,000 for direct program activity and $4,625,000 of reimbursement authority as explained later in my statement.

(2) Operations and Maintenance

This activity provides for the funding of 186 FTE employees and their work in the areas of power marketing, operation of the transmission system, maintenance of all physical facilities, and general program management. The proposed $13,132,000 budget for operations and maintenance costs is an increase of $1,350,000. The increases represent expenses primarily in the areas of service contracts, $812,000; equipment, $197,000; rental and utilities, $90,000; built-in increases for pay and benefits, $108,000; and various other expenses, $143,000.

(3) Construction

This activity provides for the construction of new, and/or modification of existing, transmission, substation, and switching facilities. The proposed $7,709,000 budget for construction is an increase of $1,890,000. Only $169,000 of this increase is for SWPA's direct program activity, and the remaining $1,721,000 is reimbursement authority as explained later in my statement.

CURRENT FINANCIAL STATUS

I am pleased to report to this Committee that SWPA is in good financial condition. All available power is under contract and is widely distributed among the six states. The Southwest again experienced excellent rainfall during FY 1986, which, when coupled with adequate rate levels, produced revenues in excess of $104,000,000. The large amount of hydroelectric energy stored in our energy banks during FY 1985 was increased slightly during FY 1986. The combination of this stored energy and the heavy rainfall, filling the system's reservoirs to maximum capacity during the first quarter of FY 1987, places SWPA in an excellent position to meet winter peak loads and continue its financial success. SWPA met its planned repayment to the treasury for the fifth straight year, in addition to paying all operation, maintenance, interest, and administrative costs. The amount repaid on principal for FY 1986 is $30,000,000, which will bring the agency's cumulative repayment to $179,634,000 on a total repayable investment of $934,871,000 or 14 percent.

REPAYMENT REFORM

This budget proposed Power Marketing rate reform legislation and assumes enactment and implementation by the end of FY 1989. These modifications would require repayment of the unpaid balance of the original Federal investment at a level not less than would be required under a fixed, straight-line amortization schedule for each power investment financed by appropriations and placed in service.

RATES

Timely rate increases have helped SWPA maintain its good financial standing. The Deputy Secretary of Energy approved, on an interim basis, a one percent rate increase for SWPA's integrated system effective October 1, 1985, through September 30, 1989. These rates were approved by the Federal Energy Regulatory Commission on July 22, 1986.

REIMBURSABLE AUTHORITY

SWPA's initiatives to reduce its need for appropriated funds has identified two areas where significant decreases can be made through the use of reimbursable authority.

The level of reimbursable authority requested is $6,346,000. Of this amount, $4,625,000 is for the elimination of duplicate appropriations for Purchase Power and Wheeling expenses, which, in the past, was requested both by SWPA and by the Department of Defense military installations which are our customers. The remaining $1,721,000 is for transmission and substation additions; and modifications of transmission lines, substations, and electronic facilities. These funds will come from various SWPA utility customers in the Southeast Missouri-Northeast Arkansas area. This activity, to be performed by SWPA, will improve and upgrade our facilities by the use of non-Federal funds and provide reliable service, presently in need of improvement.

In the past, such power purchases for military installation and power system improvements were made utilizing appropriated funds, with the funds reimbursed to SWPA by the Department of Defense and utility customers deposited with the Treasury under miscellaneous receipts.

HYDROPOWER DEVELOPMENT

SWPA continues to facilitate non-Federal financing of Federal hydropower projects. Last year we reported on the Town Bluff Project in Southeastern Texas as the historic first 100 percent non-Federal financed project in the country. As a result of the enactment of Public Law 99-662 in FY 1986, we are now working with the Cherokee Nation of Oklahoma to develop the W. D. Mayo Hydropower Project on the Arkansas River in eastern Oklahoma. The average annual energy output on this project is estimated to be 171.4 GWh, with installed capacity planned at about 40 MW.

We are also engaged in negotiations with the Grand River Dam Authority (GRDA) to develop units five and six at the Fort Gibson Dam on the Grand River in Oklahoma. These additional units each have an expected rating of 11.25 MW. Our negotiations go beyond the non-Federal financing of these additional units. We may transfer power scheduling for the entire project to GRDA, thereby providing more reliable energy, not only for the Fort Gibson project, but also for up-stream projects currently operated by GRDA. This project is a prime example of State and Federal Government working together to better serve our customers.

TRANSMISSION RELIABILITY

The Microwave System expansion scheduled for completion in FY 1987 will provide state-of-the-art communication circuits to the SCADA/AGC System, providing increased safety to our system and personnel; and improved reliability to our customers.

CLOSING

In conclusion, Mr. Chairman, SWPA's budget proposal for FY 1988 provides for the continuance of a dynamic program at a decreased funding level. We have taken initiatives to reduce appropriation requests. SWPA remains committed to operating in a business-like manner and maintaining rates sufficient to return all operating costs, along with the principal and interest associated with the construction of power generation and transmission facilities, to the U.S. Treasury. We appreciate the cooperation and recognition provided by the members of this Committee. I am privileged to serve as Administrator and to work with your Committee and with the customers and employees of the Southwestern Power Administration.

BIOGRAPHICAL SKETCH

RONALD H. WILKERSON

Ronald H. Wilkerson was appointed Administrator of Southwestern Power Administration (SWPA) on July 29, 1984 by the Secretary of Energy.

Headquartered in Tulsa, Oklahoma, SWPA is a regional agency of the U.S. Department of Energy (DOE) with responsibility for marketing Federal hydroelectric power in Kansas, Missouri, Oklahoma, Arkansas, eastern Texas, and Louisiana. SWPA's wholesale customers are 10 generation and transmission cooperatives, 45 municipal electric systems, and three military installations.

As Administrator, Wilkerson is responsible for marketing the output of 23 Federal hydroelectric projects at the lowest possible cost while fully repaying the Federal investment with interest. These projects have installed capacity of 2,150,350 kilowatts and generate an average of 5.6 billion kilowatt-hours of energy annually. Sale of power produces revenue of approximately $100 million annually against a budget of $38 million.

With about 190 employees at five locations, SWPA operates and maintains 1,400 miles of transmission lines and 26 substations in addition to scheduling and dispatching the power.

Prior to his appointment, Wilkerson was Manager of the Upper Columbia Area for the Bonneville Power Administration (BPA), a regional power marketing agency under DOE in the Pacific Northwest. He was responsible for BPA activities in eastern Washington, northern Idaho, and western Montana.

Arriving at BPA in 1961, Wilkerson progressively held more responsible positions within that organization resulting in extensive experience and expertise in the areas of customer service, power marketing, and engineering. This included serving as BPA District Manager in Kalispell, Montana, as well as assignments in Idaho Falls, Idaho; Seattle and Walla Walla, Washington; and The Dalles and Portland, Oregon.

Wilkerson is a Registered Professional Engineer, a member of the Institute of Electrical and Electronic Engineers, and serves on the Board of Directors of the Southwest Power Pool. He has received numerous awards for special acts and performance. A native of Montana, he received his Electrical Engineering degree from Montana State University.

Wilkerson and his wife, Sharon, have three sons and a daughter.

January 1986

WESTERN AREA POWER ADMINISTRATION

STATEMENT OF WILLIAM H. CLAGETT, ADMINISTRATOR

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you to discuss the Western Area Power Administration (Western) program and present the Administration's budget request for fiscal year 1988. Western values the interest, concerns, and support of this Subcommittee and is committed to operating and maintaining an electrical system that is efficient, economical, and dependable.

The coming fiscal year promises to be a challenging one for Western. I believe the FY 1988 budget proposal will allow Western to meet those challenges and accomplish our objective of fostering sales of surplus Federal energy at prices consistent with sound business principles.

MISSION, ORGANIZATION, AND STAFFING

Western is a federally operated electric power marketing administration responsible for the delivery and sale of power to over 550 wholesale customers consisting of municipalities, cooperatives, public utility districts, investor-owned utilities, Federal and State agencies, irrigation districts, and reclamation project customers. The wholesale power customers, in turn, provide service to millions of retail power consumers in our service area in the States of Arizona, California, Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Texas, Utah, and Wyoming. The largest source of power revenue is municipal utilities. Investor-owned utilities are the second largest source of revenue, with the balance derived from cooperatives, public utility districts, Federal and State agencies, irrigation districts, and others.

During FY 1988, Western will continue to be responsible for the operation and maintenance of 16,402 circuit miles of transmission line, 245 substations, and various appurtenant power facilities in a 1.3-million-square-mile geographic area. Western also constructs transmission facilities and purchases power to meet power delivery requirements.

Electric power marketed by Western will be generated at 50 hydropower plants operated by the Bureau of Reclamation (BuRec), the U.S. Army Corps of Engineers (Corps), and the International Boundary and Water Commission, U.S. Section. In addition, Western plans to market any energy not needed for project pumping from the Navajo coal-fired plant near Page, Arizona. The installed generating capacity of all these powerplants will be 9,193 megawatts.

A personnel staffing level of 1,379 full-time equivalents is requested in FY 1988 to accomplish Western's objectives, the same as FY 1987.

BUDGET HIGHLIGHTS

For FY 1988, Western's program level request for the construction, rehabilitation, operation and maintenance activity is $300.0 million, an increase of $16.2 million above the FY 1987 level. The program increase is mainly attributable to increased purchase power and wheeling costs for the Central Valley Project (CVP) in California; to increased power system facility replacements and additions, including consolidation of the Hoover Powerplant transmission facilities at the Mead Substation in southern Nevada; and to increased costs of maintaining an interconnected power system.

In addition to our request for new budget authority, we are requesting FY 1988 obligational authority of $87.0 million for the Colorado River Basins Power Marketing Fund (CRB Fund), an increase of $5.0 million above FY 1987. This increase is primarily because of higher estimated costs for power purchases for firming needs and fuel displacement activity. Under the CRB

Fund, encompassing the Colorado River Storage Project (CRSP), the Fort Peck Project, and the Central Arizona Project (CAP), all operation and maintenance and power marketing expenses (including a portion of similar expenses incurred by the BuRec and the Corps) are financed from project power receipts collected by Western.

Specific appropriation or fund amounts requested in FY 1988 compared to the FY 1987 level are as follows:

BUDGET REQUEST SUMMARY
(Dollars in Thousands)

Appropriation or Fund/Activity	FY 1987	FY 1988 Request	Change
Construction, Rehabilitation, Operation and Maintenance			
Construction and Rehabilitation	$ 83,275	$ 85,000	+$ 1,725
System Operation and Maintenance	86,100	93,000	+ 6,900
Purchase Power and Wheeling	114,400	122,000	+ 7,600
Subtotal (Program)	$283,775	$300,000	+$16,225
Use of planned unobligated balances (net)	-43,466	- 4,485	+ 38,981
Subtotal (Budget Authority), Construction, Rehab., Operation and Maintenance	$240,309	$295,515	+$55,206
Colorado River Basins Power Marketing Fund (Obligational Limitation)	82,000	87,000	+ 5,000
Total Budget Request	$322,309	$382,515	+$60,206

CONSTRUCTION AND REHABILITATION

The total FY 1988 construction and rehabilitation activity requirement is $85 million, including $84.1 million of new budget authority and application of prior year balances of $0.9 million.

During FY 1986, work was completed on 16 substation additions, over 340 miles of transmission line, and other relatively minor facility additions. In the current fiscal year, we plan to complete work on eight substation additions. Over 330 miles of transmission line will also be reconductored, rebuilt, or constructed in FY 1987.

Of the FY 1988 total program activity requirement of $85 million, $39.3 million or 46 percent is needed to complete work on 14 substation additions, 1 communication system addition, and 2 operation and maintenance building additions. Approximately 100 miles of transmission line will also be reconductored, rebuilt, or constructed in FY 1988. Work will continue on the Western Colorado 345-kV additions, virtually all of which are now under contract. This project is scheduled for completion in 1989. In addition, Western will continue other transmission line improvements and substation equipment additions.

Approximately $26.1 million, or 31 percent of the total requirement of $85 million, is for new Western contract awards for 7 transmission line additions and improvements in 5 States, 6 substation additions, and 7 operation and maintenance service center additions. Only 2 of the 7 transmission lines, the Craig-Bonanza 345-kV transmission line and the Lawrence Livermore-Tracy 230-kV transmission line, involve new construction beyond normal replacement or upgrading.

Craig-Bonanza Transmission Project

Western is participating in an effort to construct a 345-kV transmission line between the Craig Generating Station near Craig, Colorado, and the Bonanza Generating Station near Bonanza, Utah. Other project participants include Tri-State Generation and Transmission Association, Deseret Generation and Transmission Cooperative, Pacific Power and Light Company, Utah Associated Municipal Power Agency, Platte River Power Authority, and the Utah Municipal Power Agency. Construction of the line will add stability and reliability to the existing system by alleviating a bottleneck to east-west power flow, provide a high-voltage connection to deliver reserve power to northeastern Utah, assure that Western can meet its present and increasing contractual obligations, and provide the opportunity for other utilities in the area to meet their present and forecasted power needs.

Lawrence Livermore-Tracy 230-kV Transmission Line

Western has been asked by the Department of Energy's San Francisco Operations Office (DOE/SAN) to construct a transmission line from Western's Tracy Substation to the Lawrence Livermore National Laboratory (LLNL). Although the primary purpose of this line is to improve the security and reliability of electric service to LLNL, DOE will realize lower overall costs of receiving Federal Central Valley Project electric power at LLNL and other nearby DOE operations.

The 12.5-mile line and associated terminal facilities are estimated to cost $5.1 million. An additional $13.5 million is required for integration of the line with the current electrical system at LLNL. $2.3 million has been included in the FY 1988 budget request to initiate construction of this project.

Studies for Future Facilities

The balance of $19.6 million, or 23 percent of the $85 million request, is to continue engineering analyses, land services, and environmental and planning studies to maintain system capability, to deliver firm power to customer loads, and to explore mutually beneficial transfers of power to adjacent systems or regions. Because of the interdependence of the various electric utility systems, Western coordinates and conducts most of its planning studies as joint efforts with other utility groups. These groups presently consist of 2 regional reliability councils (Western Systems Coordinating Council and Mid-Continent Area Power Pool), 4 power pools, and over 25 different project study groups. Western's primary goal in pursuing joint study efforts is to optimize the use of transmission system additions and improvements in an effort to increase overall system efficiency, lower the cost of system operation and maintenance, minimize environmental impacts, and reduce the need for Federal appropriations. These studies include such efforts as the California-Oregon Transmission Project, the Pacific Northwest-Southwest Intertie, and transmission into the State of Kansas.

POWER MARKETING AND OPERATION AND MAINTENANCE

The total FY 1988 power marketing and operation and maintenance activity request is $93.0 million, including $89.4 million of new budget authority and application of prior year balances of $3.6 million. Our FY 1988 appropriation request of $89.4 million for power marketing and operation and maintenance includes $7.0 million of permanent budget authority for the Boulder Canyon Project. The increase of $6.9 million above Western's FY 1987 level in total program activity is attributable to replacing and adding electrical and communication equipment, higher costs of maintaining an interconnected power system, and increasing prices for goods and services.

Of the FY 1988 program total, $74.4 million or 80 percent is for regular transmission system operation and maintenance expenses. This includes classified and wage board employee salaries, travel and transportation, rents, communications, utilities, materials and supplies, data processing, conservation and renewable energy activities, and administrative and general expenses.

In addition, $18.6 million or 20 percent is requested for power system replacements and additions necessary to maintain and improve system reliability, stability, and operation efficiency. This includes consolidation of Hoover Powerplant transmission facilities; the purchase of telemetering, supervisory control, microwave, radio, and protective relaying equipment; circuit breakers and transformers; the replacement and disposal of equipment containing polychlorinated biphenyls (PCBs); the inspection and treatment of wood poles; and the replacement of deteriorated wood-pole transmission structures.

Operation and Maintenance Productivity Reviews

In April 1986, Western began performing a series of productivity reviews of the five major functional areas within operations and maintenance. The purpose of the reviews is to assess the efficiency, effectiveness, and economy of the work being performed and to effect changes and improvements in organization, staffing, and work practices to increase productivity and program delivery. A productivity review of the power system operations function was completed in October 1986. Our budget request reflects annual savings of $700,000 as a result of implementing the review's recommendations. The last review in the series is scheduled to be completed by October 1988.

Marketing Plan Status

Final power allocations for the Western Division of the Pick-Sloan Missouri Basin Program, the Fryingpan-Arkansas Project, the Parker-Davis Project, and the Salt Lake City Area Integrated Projects (Colorado River Storage, Rio Grande, and Collbran Projects) are expected to be completed this year.

Prototype sales contracts associated with these marketing plans either have been, or will shortly be, prepared and distributed to potential allottees for preliminary review and comment. Contract negotiations with individual allottees will begin during the summer of 1987 and are expected to be completed by the end of 1988.

Utah Power and Light Company Lawsuit

The Utah Power and Light Company and 158 of its full-service customers filed suit challenging the constitutionality of the preference provisions of Federal reclamation law. The complaint was filed on October 31, 1986, in U.S. District Court in Salt Lake City. The suit challenges the provisions of Western's post-1989 power marketing criteria and proposed allocations for the Colorado River Storage Project, certain of Western's other power sales programs, the Craig-Bonanza Transmission Line, Western's conservation program, and Western's compliance with environmental laws in promulgating and implementing these programs.

Western is working with the Department of Justice in preparing a defense to the suit so that Western's marketing program remains fully consistent with all applicable laws and the expressed desires of Congress.

Conservation and Renewable Energy

In FY 1988, $3.7 million is requested for the Conservation and Renewable Energy (C&RE) program (including activities under the Revolving Fund). The C&RE assistance program facilitates the adoption of programs by Western's customers which demonstrate good stewardship of the natural resources through efficient end-user applications of the most practical and effective technology.

Status of Water Conditions in Western's Marketing Area

Based on the January 1987 "Water Supply Outlook for the Western United States," published by the Departments of Agriculture and Commerce, major river basins in the Western

United States should generally produce slightly below-normal flows this spring.

The current 1987 outlook is for below-normal runoff in California in the Sacramento, San Joaquin, and North Coastal (i.e., Trinity) River Basins. Assuming normal water conditions for the remainder of this year, below-normal energy output will result for the CVP hydropower facilities.

The total annual runoff for the Missouri River Basin is expected to be near the long-term normal runoff. Current mainstem Missouri River carryover storage is higher than the desirable storage target at this time of year.

The water supply outlook for the Colorado River Basin is for near-normal runoff. Current reservoir storage remains high. The April to July inflow forecast for Lake Powell, made in mid-January, was 9.25 million acre-feet or 114 percent of the 20-year average inflow.

PURCHASE POWER AND WHEELING

The total request for FY 1988 purchase power and wheeling activities is $122.0 million. In addition, Western has power credits amounting to $111.9 million from net billing ($27.3 million), bill crediting ($49.6 million), and nonappropriation transfers ($35.0 million) which partially offset appropriation requirements. The program activity provides for the purchase and wheeling of power to meet existing contractual commitments and for Western's participation in the fuel displacement activity. The increase of $7.6 million from the 1987 program activity level is primarily due to increased energy and capacity costs for the Central Valley Project in California.

In 1986, Western displaced the equivalent of approximately 8,765,265 megawatthours of energy or the equivalent of

18.3 million barrels of oil through its fuel displacement activity.

POWER CONTRACTS, RATES, REVENUES, AND REPAYMENT

Status of Hoover Contracts

The Hoover Power Plant Act of 1984 authorizes Western to allocate power and enter into contracts involving the sale of power and the uprating of the Hoover Powerplant units. The contracts to implement this uprating are in the process of being executed by the Hoover allottees and Western. Western's contract offer is open to all 15 allottees until March 15, 1987. The uprating program is on schedule, as signed electric service contracts received by Western allow for the advancement of funds to the Bureau of Reclamation for construction work.

Status of Project Power Rate Adjustments

In order to meet repayment obligations, rate adjustments were recently initiated for the Federal portions of the Navajo Powerplant of the Central Arizona Project, the Fryingpan-Arkansas Project, the Rio Grande Project, the Salt Lake City Integrated Projects (which include the Colorado River Storage Project, the Collbran Project, and the Rio Grande Project), the Washoe Project, and the Boulder Canyon Project. Recently initiated rate adjustments, excluding the Navajo Powerplant, are expected to result in additional annual revenue of approximately $24 million.

Based on preliminary study analyses, rate adjustments are expected to be initiated in the near future for the Central Valley Project, the AC portion of the Pacific Northwest-Pacific Southwest Intertie Project in Arizona and Nevada, and the Pick-Sloan Missouri Basin Program.

Rates for the Boulder Canyon, Central Arizona-Navajo, and Falcon-Amistad Projects are currently adjusted either annually or monthly in accordance with repayment formulas set by contract or regulations.

Power Revenue and Energy Sales

During FY 1986, Western marketed 45.0 billion kilowatthours (kWh) of available energy to wholesale power customers and received electric service revenues of $642.4 million. Our estimate for FY 1987 energy sales and revenues is 38.3 billion kWh and $630.7 million, respectively. For FY 1988, energy sales are estimated at 35.4 billion kWh and revenues are estimated at $630.4 million.

Above-normal runoff in the Colorado River Basin in FY 1986 resulted in greater nonfirm energy for sale and higher revenue than was initially projected. Energy sales decline after FY 1986 primarily because of the Colorado River Basin Project shift of energy to project use pumping, and assumption of a return to average water conditions in FY 1987.

Power Repayment

As of September 30, 1986, the investment to be repaid by Western's power system revenues totaled approximately $4.1 billion, of which $1.9 billion has been repaid. Cumulative power receipts total $6.9 billion and have been applied as follows: $2.5 billion for operation and maintenance and other expenses; $1.2 billion for purchase power and wheeling; $1.3 billion for interest; and $1.9 billion for repayment of investment in facilities and assistance to irrigation. In FY 1986, $134.0 million was applied to repayment of investment. To date, 45 percent of the investment assigned to power for repayment has been repaid.

The following table summarizes Western's repayment status by project:

STATUS OF REPAYMENT AS OF SEPTEMBER 30, 1986
(DOLLARS IN MILLIONS)

Project Power System	Initial Year of Repayment Studies	Cumulative Power Revenues	Cumulative Exp. *	Power Investment**	Nonpower Investment to be Repaid by Power	Deferred Expense	Invest. Repaid to Date	Unpaid Bal. of Invest.
Boulder Canyon 1/	1937	$598	$460	$157 2/	$ 25		$ 138	$ 44
Central Valley	1944	1,584	1,369	436	95	$ 73	215	389
Collbran	1963	12	11	11	5		1 3/	15
Colorado River Basin (Navajo)	1974	645	565	--	80		80	
Colorado River Storage 4/	1963	1,199	773	751	117		426	442
Falcon-Amistad	1955	27	21	44	--		6	38
Fryingpan-Arkansas	1982	11	19	93	--	8	--	101
Pacific Northwest-Pacific Southwest Intertie 5/	1968	26	26	68	--	27	--	95
Parker-Davis	1942	418	232	147	27		186	<12>
/Pick-Sloan Missouri Basin 6/	1950	2,365	1,542	1,303	661		823	1,141
Rio Grande	1949	39	38	7	5		1	11
TOTAL		$6,924	$5,056	$3,017	$1,015	$ 108	$1,876***	$2,264

* Cumulative Expenses includes operation and maintenance, purchased power, interest, and other costs paid from revenues.

** Power Investment does not include Deferred Expense or repayment assistance to nonpower investment, primarily irrigation investment. Nonpower Investment and Deferred Expense are shown as separate columns.

*** Cumulative Power Revenues less Cumulative Expenses does not equal Investment Repaid to Date due to the inclusion of $8 million reflected as actual expenses for the Fryingpan-Arkansas Project.

1/ Data for Boulder Canyon Project is through the Operating Year, which ended May 31, 1986.
2/ Includes $25 million flood control investment, which will be repaid from power revenues beginning in 1987.
3/ Repaid to date is $529,000, which was rounded to $1 million.
4/ Includes the Provo River Project.
5/ AC facilities only.
6/ Includes the four integrated projects (North Platte, Shoshone, Colorado-Big Thompson, and Kendrick).

Repayment Reform

The Administration plans to submit legislation to modify power marketing administration capital investment repayment practices, effective October 1, 1988 (FY 1989). These modifications would require repayment of the unpaid balance of each Federal power investment at a level not less than would be required under a fixed, straight-line amortization schedule for each power investment financed by appropriations and placed in service. This requirement would also apply to irrigation investments assigned to power for repayment. Repayments of principal, if necessary, could be deferred, subject to the same terms and conditions applicable to deferred interest payments (e.g., current interest rates are used because the deferral helps finance current operations).

The following table is Western's current estimate of the increased revenue that will be generated in FY 1989-1992 as a result of the proposed repayment reform.

IMPACTS OF REPAYMENT REFORM
(DOLLARS IN THOUSANDS)

	FY 1989	FY 1990	FY 1991	FY 1992
Estimated revenues using existing repayment method	$622,600	$631,177	$663,136	$685,775
Estimated increase attributable to repayment reform	21,000	28,200	29,300	28,100
Estimated revenues after repayment reform	$643,600	$659,377	$692,436	$713,875

This concludes my statement of Western's FY 1988 budget request and program status. Mr. Chairman, I would be pleased to respond to any questions you or the Subcommittee members may have.

BIOGRAPHICAL SKETCH

WILLIAM H. CLAGETT
Western Area Power Administration

William H. Clagett was appointed Administrator of the Western Area Power Administration (WAPA) by Secretary of Energy John S. Herrington on March 19, 1985. Clagett was the Deputy Administrator with WAPA from 1978 to 1984.

WAPA markets and transmits federally produced power in a 15-state area.

Clagett graduated from Oregon State University in 1962 with a Bachelor of Science Degree in Business and Technology. He began his Federal career with the Bonneville Power Administration (BPA) in Portland, Oregon, in 1962. In 1966, he was assigned to the Area Office of BPA in Idaho Falls, Idaho, as an electrical engineer and was named Area Manager in 1970. The following year, he was appointed Assistant Administrator at BPA and assigned to the Washington, D.C. Office. He remained with BPA until transferring to WAPA.

In 1984, Clagett served as Acting Administrator for the Southwestern Power Administration headquartered in Tulsa, Oklahoma.

Clagett has served in various capacities on the Western Systems Coordinating Council, including the position of Chairman. He also serves on the Board of Trustees for the North American Electric Reliability Council.

Clagett and his wife, Brenda, have a son and daughter and reside in Littleton, Colorado.

SUBCOMMITTEE RECESS

Senator HATFIELD. We will, then, stand in recess until 2 p.m. Monday, when Secretary Hodel will make his presentation. The hearing is recessed.

[Whereupon, at 3:03 p.m. Thursday, March 12, the subcommittee was recessed to reconvene at 2 p.m. Monday, March 16.]

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

WEDNESDAY, MARCH 18, 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2 p.m. in room SD–138, Dirksen Senate Office Building, Hon. J. Bennett Johnston (chairman) presiding.

Present: Senators Johnston and McClure.

DEPARTMENT OF ENERGY

SOLAR AND RENEWABLE AND GENERAL SCIENCE PROGRAMS

STATEMENT OF HON. DONNA R. FITZPATRICK, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

ACCOMPANIED BY ROBERT L. SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY

Senator JOHNSTON. The subcommittee will come to order.

This afternoon, we continue our review of the fiscal year 1988 budget, and welcome to the committee Donna R. Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy, who will present the solar and renewable request; Dr. Alvin W. Trivelpiece, Director of the Office of Energy Research, who will present the energy research budget; and Mary L. Walker, Assistant Secretary for Environment, Safety and Health, who will present that Office's budget request for environmental and safety programs.

SOLAR AND RENEWABLE ENERGY PROGRAMS

PREPARED STATEMENT

We will hear first from Assistant Secretary Fitzpatrick. We, of course, will place your full statement in the record. Please proceed as you wish.

Miss FITZPATRICK. Thank you, Mr. Chairman. I would just like to thank you for putting my full statement in the record.

I would like to say, very briefly, that I believe that our request for renewable energy research and development is a lean budget, but an adequate budget to address the basic technology issues that remain to be solved so that renewable energy sources can become a vital part of the energy base for the United States.

I am prepared to answer any questions the subcommittee may have.

[The statement follows:]

STATEMENT OF DONNA R. FITZPATRICK

Mr. Chairman and Members of the Subcommittee:
I appreciate the opportunity to appear before you today and provide information on the FY 1988 budget request concerning the Department's renewable energy, electric energy systems, and energy storage programs. The proposed levels of funding will provide for continuing progress in development of the technology base required for industrial decision making and are appropriate given the federal role and the need to progressively reduce federal budget deficits.

RENEWABLE ENERGY OVERVIEW

The availability of stable and secure sources of energy will continue to play an important role in sustaining a robust, productive, and competitive economy. The Department's renewable energy programs reflect a continuing commitment to diversify U.S. sources of energy supply in a manner that fosters marketplace choices for the Nation's energy suppliers and users. Renewable energy is an important part of the Nation's energy supply mix, and renewable technologies already are making significant contributions to national, regional, and local energy requirements. These contributions are possible because the family of renewable energy technologies spans a wide range of resource and technical options. These contributions should increase because, while some technology and resource combinations have been supplying substantial energy for many years, others are just beginning to enter the supply system and some remain in research phases.

During the past decade major advances have been made in all of the renewable energy technologies. New materials have been developed with the thermal, optical, and physical properties required for lower cost and higher performance. New components have been tested and substituted for less effective ones. Extensive systems analysis has been performed and hundreds of systems have been studied under both controlled laboratory conditions and conditions typical of field operation. Teams of scientists and engineers in Government laboratories, universities, and industry have created a solid technology base and expertise in a broad array of disciplines pertaining to renewable energy technologies.

It has been demonstrated that renewable energy sources can complement conventional energy sources and help provide secure alternatives in the event of energy supply interruptions or price increases. Renewable energy resources, when used with appropriate conversion and storage systems, can offer direct matching of various energy requirements with locally-available energy resources. The modularity of renewable energy equipment allows additions to be made in comparatively small increments, resulting in decreased lead time, reduced planning uncertainties, and comparatively small capital outlays. In rapidly changing and uncertain energy markets, this modularity offers significant economic benefits for energy producers and consumers.

Aside from hydroelectric systems, renewable energy technologies have not yet realized their potential for providing these advantages in the competitive energy marketplace. Additional R&D is required to bring them to competitive viability while maintaining the integrity and safety of the Nation's supply network. Long-term cost and demand projections indicate that many of these options represent attractive energy supply alternatives; however, the short-term outlook tends to discourage renewable energy investment. Accordingly, continued Federal investment in renewable energy R&D appears prudent to ensure that a reasonable number of renewable energy supply options is available to the private sector in the long term.

The renewable energy budget request includes production, storage, and distribution technologies that vary considerably in their technical maturity and current economic viability. As a general rule, Federal funding is concentrated in basic and applied research and development that is conducive to informed decision making by the private sector regarding further development. Federal attention is concentrated on scientific and engineering research necessary for a better understanding of basic resource and technology phenomena, methods to use these resources for producing competitive and useful forms of energy, and important crosscutting technologies for storage of energy and for reliable and efficient management of the electric energy supply network.

Within the current Federal budget limitations, the Department will concentrate its efforts on the highest priority research to address the most critical technology base issues. The focus of such efforts will be on those technologies with the greatest long-term promise for contribution to the Nation's energy supply mix. These efforts will emphasize research critical to advancing technology while avoiding interference with the capacity of industry to develop specific commercial products and services. The Department will continue to encourage private sector participation and seek input from industry and other institutions in the selection of projects that have the greatest relevance and potential.

The request for FY 1988 of $101.1 million will assist the Department in performing the activities that reflect the Nation's commitment to continued development of renewable energy resources, thereby increasing the Nation's energy supply options and national energy security.

I would now like to address the funding requests for selected major programs.

SOLAR BUILDINGS

Research has confirmed that significant increases in the supply of solar energy to buildings can be obtained through emerging developments in such fields as electrochemistry, holography, optical physics, and advanced materials. For example, current research indicates that application of these developments to such solar technologies as switchable glazings, commonly referred to as "smart windows", and advanced phase change thermal storage wallboard materials could potentially double the present solar energy contribution to building heating energy requirements. The FY 1988 Solar Buildings Program budget request of $5.25 million for operating expenses, and $0.15 million for capital expenses, will continue progress in establishing the essential technology base required for industrial development of these and other promising new materials, systems, and related technologies. The goal of these research activities is to increase the energy contribution of solar technologies to the point where 70% to 80% of space heating, hot water, cooling, and lighting requirements of many different types of buildings could be supplied at costs that are competitive with conventional fuels.

The FY 1988 program in materials and components includes continued research on new optical and thermal switching films which control solar gain and thermal losses for windows and exterior building surfaces. The switchable film technology has made a large step forward with the recent development of a low-cost process to deposit one of the five layers of a switching film, the counterelectrode layer, on window glass. Work will continue on materials for the optical switching layer itself. Research on innovative collector materials will continue in order to increase thermal efficiencies and reliability, decrease costs, and expand the application of solar technologies to cooling systems and other building energy requirements. For solar cooling, desiccant materials research has led to prototype dehumidifier systems with substantially improved performance using microbead silica gels. However, several organic materials show promise of dramatic increases in moisture absorptivity and will be experimentally evaluated in FY 1988. New phase change materials incorporated in such conventional building materials as wallboards will make it possible to store and use thermal energy provided by solar energy in all parts of the building. Recent laboratory tests have shown that several candidate solid-liquid phase change materials can dramatically increase wallboard heat capacity while meeting self-extinguishing fire tests. Solid-solid phase change materials that should have wider applicability in a variety of building materials will be investigated in FY 1988.

Systems research will continue for both residential and non-residential heating, cooling, and daylighting building applications. Research on open cycle solar absorption and solar desiccant cooling technologies will be aimed at increasing their energy efficiencies, the key to achieving viable solar cooling applications. An important element of the FY 1988 systems research program is the continued development of analytical tools to allow architects, engineers, and homebuilders to predict the performance of systems using advanced materials. In particular, analysis techniques will be developed for integrating these solar technologies with conventional heating and cooling systems. Researchers will also continue to monitor, analyze, and evaluate the performance and reliability of currently employed solar building technology.

PHOTOVOLTAICS

Photovoltaics (PV) continues to make progress toward becoming a significant energy supply option. The partnership between DOE and industry has produced increased conversion efficiencies and reliability and reduced costs, all of which have helped the technology to establish a strong foothold in the competitive energy market, with a broad range of viable applications. In FY 1988 the Photovoltaic Program, with a budget request of $20.1 million for operating expenses and $0.3 million for capital expenses, will seek to advance the basic understanding of technical and scientific issues associated with materials formation and physical phenomena of the PV cell.

Amorphous silicon is an attractive thin-film photovoltaic material which could lead to wide-spread viability for electric power production applications. U.S. research leads worldwide efforts in addressing the issues leading to the optimization of single junction submodules and in the investigation of higher efficiency multijunction concepts. Research and development of amorphous silicon will continue into FY 1988 both as part of an on-going 50:50 partnership with U.S. industrial organizations and with basic work with several universities. The objective of these activities is to achieve 10 percent efficient single junction and 13 percent efficient multiple junction large area submodules.

Polycrystalline thin films also represent promising candidates for meeting the major programmatic criteria relating to cell efficiency, material processing requirements, and performance stability. Progress has been made in the development of low cost deposition methods and increased cell efficiency. FY 1988 efforts will concentrate on defining the scientific and technological barriers to approaching theoretical efficiency which may be as high as 20 percent, and on the development of large area film fabrication concepts for the most promising of these materials.

Partially as a result of DOE's program, single-crystal gallium arsenide and single-crystal silicon solar cells currently hold records for the most efficient photovoltaic conversion of sunlight to electricity. But the efficiency of such materials is inherently limited because not all incident sunlight can be utilized due to the frequency selectivity of the specific materials involved. To overcome this difficulty, researchers will continue to explore concepts such as seeking improvements in selected single-junction cells, exploring ways to mechanically or optically couple cells, and fabricating, as one structure, two or more cells of different materials. The goal of this high priority effort is to achieve 35% efficient small area cells for use by industry as part of its development effort.

The FY 1988 Program will also maintain the unique capability at SERI for precise measurement of material and cell parameters. This work guides researchers throughout the U.S. in understanding and correlating observed physical phenomena. The program will also support other fundamental research in ternary and quarternary compounds and promote basic material work at universities. Finally, the wealth of information, from basic materials theory to complex operations, gathered by the program during its ten years of research and development will be used to assist U. S. industry in their efforts to bring photovoltaic technology to competitive maturity, domestically and internationally. This will be accomplished through report publications, workshops, and technical meetings with the help of the Design Assistance Center.

SOLAR THERMAL TECHNOLOGY

Solar Thermal Technology has begun to attract private commitment to early market opportunities and has the prospect of being competitive with other electric generating systems in the 1990s. Two privately financed 30-megawatt, distributed solar thermal electric plants have recently been placed in service in

California. The new units bring the cumulative generating capacity of solar thermal plants to over 110 MWe, enough to meet the electrical needs of more than 55,000 homes and businesses. Three more 30-megawatt plants are scheduled to be placed in service by early 1988 in the same California location. If all existing contracts are completed, it would bring the total capacity to over 550MWe from solar thermal plants. Solar thermal plants, while relying on tax incentives and third party financing, are developing valuable field experience concerning solar thermal reliability in a utility setting - experience that is invaluable as more cost efficient technology emerges from the government/industry R&D partnership.

A new generation of parabolic dish and central receiver technologies is being pursued that have the potential for significantly reducing the cost of solar thermal systems while also increasing performance and reliability. These new concentrators, receivers, and energy conversion devices have the potential to reduce the cost of electricity from the present 13¢/kWh to 5 - 7¢/kWh for electric power production and to $9/MBtu -- the long-term goals to make solar thermal technology competitive with other energy generating options without tax incentives. During the past year, the Department issued the Solar Thermal "Five-Year Research and Development Plan." This document, whose development was closely coordinated with industry, utilities, and academia, provides a clear research and development path for establishing solar thermal technologies as a viable energy alternative in the 1990s. The FY 1988 program, with a budget request of $14.1 million, emphasizes activities which address the critical technical uncertainties and performance and cost improvements necessary to achieve the stated energy cost goals.

Central receiver heliostats and parabolic dish concentrators of 150 to 200 square meters have been constructed and are under evaluation at the Solar Thermal Test Facility in Albuquerque, New Mexico. These units are three to four times larger than earlier sizes, while unit area costs have been reduced by 40%. A new generation of concentrators, using membranes reflectors in lieu of heavier glass reflectors and support structures, has the potential to further reduce the heliostat and parabolic dish concentrator weight by 75% and further reduce costs by another 50%. A 50 square meters stressed membrane heliostat is currently being evaluated at the Test Facility. Research on 150 square meters stressed membrane heliostats with industry will continue in FY 1988. Cooperative efforts initiated in FY 1987 will also continue with industry to develop stretched membranes for dish concentrators.

Central receivers using molten salt or sodium as heat transfer fluids would allow reductions in receiver size and development of low pressure receivers that weigh less and require less expensive support structures. Research efforts in this area have established the basis for reducing receiver and storage cost by 50%, improving both the overall plant cost and levelized energy costs of solar thermal systems. Operation of a molten salt receiver incorporating commercial design features will begin in FY 1987. The development and testing of molten salt valves, pumps, receivers, and advanced control subsystems will continue through FY 1988. Development of the free-piston Stirling engine, in cooperation with NASA, will continue in FY 1988 for use on parabolic dishes. This engine has the potential to achieve the long-term goals of high reliability and performance at competitive cost. Additional parabolic dish research projects which are underway and will continue in FY 1988 include the development of a thermochemical cell to produce electricity in which the spent chemicals are regenerated by solar energy.

Researchers will continue to study approaches for replacing the sensible heat transport methods with thermochemical energy transport and storage processes which have the potential to dramatically reduce thermodynamic losses and thereby increase overall efficiency.

BIOFUELS

Biofuels energy technologies utilize a variety of organic feedstocks, such as wood and other terrestrial crops, aquatic plants, and municipal and other wastes that can be converted by thermochemical and biochemical processes into energy sources. Biofuels currently are supplying approximately 2.8 quads, or almost 4 percent, of the U.S. energy supply, primarily from the combustion of wood. However, in the longer term, increased usage will come from biofuels - derived gaseous and liquid fuels which have the potential for significant additional contributions. During FY 1988, the Biofuels Program will concentrate on those technologies with the greatest potential for producing liquid and gaseous fuels, focusing on five fuel cycles that integrate biofuels feedstock production and conversion technologies. These fuel cycles produce liquid fuels, such as alcohol, bio-crude oil, and plant oil-derived gasoline/diesel substitutes, and gaseous fuels from terrestrial and aquatic energy crops and wastes. The FY 1988 budget request for Biofuels Energy Systems is $10.65 million.

Terrestrial crops production research includes wood produced by short-rotation intensive culture (SRIC) and herbaceous energy crops (HEC). SRIC reserve has been concentrated on the six most promising species of hardwoods. This effort includes biogenetic techniques to improve both the production and site adaptability of selected species of hardwoods and the evaluation of the stability and inheritability of desired traits. Results from prior years' field trials will be used to update models of coppice dynamics and develop stand establishment recommendations for the selected SRIC species. Oilseed crops breeding research will develop new strains with enhanced energy characteristics. Biotechnology research will be initiated on SRIC and HEC to improve the suitability of feedstocks for specific conversion techniques by altering the genetic characteristics and composition of selected strains.

Aquatics research continues to concentrate on the physiological characterization of specific strains that are being selected for advanced productivity and lipid enhancement/regulation research. Research will be initiated to genetically improve lipid composition. In addition, an outdoor test facility will be operated to gather data on the productivity of laboratory strains.

Thermochemical energy conversion research will focus on liquefaction and pyrolysis of biofuel feedstocks to produce high-value liquid and gaseous fuels. Construction of an experimental medium Btu gasifier will be initiated with prior year funds. Gaseous fuels research will switch to a process for the direct conversion of high-moisture feedstocks to methane and other combustible gases. Thermochemical liquid fuels research will continue on processes that directly convert wood to bio-crude oil and on the processes necessary to upgrade that oil to a feedstock for existing petroleum refineries. In addition, research will be initiated that will examine the relationships of municipal solid waste characteristics (size, purity, etc.) to specific conversion processes.

The biochemical conversion fuel cycles produce liquid and gaseous fuels directly from high moisture feedstocks. Hydrolysis/fermentation technologies produce alcohols directly from energy crops and wastes. In FY 1988 research will concentrate on enzymatic hydrolysis of lignocellulosic feedstocks and on the evaluation and testing of advanced microbial enzyme production systems and acid hydrolysis/fermentation systems. Experimenters will attempt to optimize the process dynamics and conversion efficiencies. Anaerobic digestion, another form of biochemical conversion, produces a methane and carbon dioxide mixture that can be used directly as a boiler or transportation fuel or can be purified to natural gas quality. Anaerobic digestion research will involve the biochemistry of the complex microorganisms and the optimization of reactor conditions, operation, and control.

WIND ENERGY

The year 1986 saw continued expansion of wind turbine capacity with an estimated 300 megawatts capacity added, bringing the installed base to 1400 megawatts. The average size of wind turbines increased in 1986, to slightly over 100 kW. While the rate of capacity growth has slowed and fewer commercial firms exist, a number of stronger manufacturers and developers are continuing research and development and are beginning to explore overseas markets, often with assistance from the Committee on Renewable Energy Commerce and Trade.

The objectives of the Department's Wind Energy Program are to improve the understanding of the fundamental atmospheric physics of wind turbines and to translate this understanding into tools that industry can use to design and develop more reliable, efficient, and cost-competitive wind turbines. The FY 1988 request for Wind Energy is $8.1 million for operating expenses and $0.4 million for capital equipment. These funds will support two basic types of research: the basic science of wind turbine dynamics that includes atmospheric fluid dynamics, aerodynamics, and structural dynamics, and (2) advanced components and supporting research, in which improved airfoils, variable speed operation, wind/diesel controls, acoustic noise generation and propagation, and systems analysis are studied.

In the area of wind turbine dynamics, FY 1988 efforts will be undertaken to increase understanding of turbulence, which is a major issue for performance and design loads, and the effects of terrain on general patterns of wind flow and turbulence that strongly affect energy production and structural stresses in wind farms. A cooperative analysis will be undertaken with industry to ascertain why some turbines have unaccountably experienced extensive structural damage in the windfarm environment. Research evaluations will include wind tunnel and field studies to observe key elements of unsteady flow and performance validation of existing models through cooperative research. Structural dynamics experiments will be performed to correlate the wind input to machine stresses through single and multiple tower arrays close in to the turbine. Several fatigue projects will be undertaken in concert with industry and a multitower array will be employed in an experiment involving the combined experience of the national labs and industry to provide an extensive data set for subsequent structural analysis.

In the advanced components area, field testing will be performed on two families of improved airfoils, both of which have considerable retrofit potential for existing turbines and are of keen interest to industry. Field testing of variable speed control systems through cooperative research is anticipated. Airfoil development efforts will be continued, guided by results from the basic sciences area. Research will also be undertaken to better understand the design and operation of wind/diesel systems, develop procedures for estimating wind turbine noise, and to overcome barriers such as concern about utility power quality.

OCEAN ENERGY

The Ocean Program conducts research and development on ocean thermal energy conversion (OTEC) technology to a point at which the private sector can make informed assessments of whether applications of the technology are viable energy supply alternatives. This is accomplished principally through research on components and systems modelling. The long-range goal of the OTEC program is to achieve sufficient advancement in technology to result in a projected capital cost of $3200/kWe (1984 dollars). The program strategy focuses on reducing the technical uncertainties which would be associated with 5-15 MWe, near-shore, island based systems. This size appears to be appropriate for the most likely initial OTEC markets. The FY 1988 budget request is $3.0 million for operating expenses.

In FY 1988, the program will emphasize two areas of research: Experimental Verification and Testing, and Thermodynamic Research and Analysis. Two previously supported research areas -- Material and Structures Research, and Oceanographic, Environmental, and Geotechnical Research -- have provided a data base that is useful for the two FY 1988 research areas, and do not currently require the degree of emphasis that was necessary in past years.

The objective of the experimental verification and testing program is to verify functional feasibility, performance, and operational characteristics of OTEC components, such as heat exchangers and process controls, on a scale that can be extrapolated by industry in designing small plants. During FY 1988, DOE will conduct a set of open cycle OTEC component heat and mass transfer experiments leading to tests at the 165kW level, which is considered to be the point from which extrapolations can be made. In order to conduct seawater tests and experiments at this level, DOE is contributing to the upgrading of a test facility currently being undertaken by the State of Hawaii.

One objective of the thermodynamic research and analysis program is to experimentally determine the effects of trapped gas bubbles and actual seawater on the open-cycle conversion process. Work will be continued on specifying the performance requirements and initial configuration of the low pressure power converter to be employed in the 165 kW open cycle tests. The program will also experimentally validate selected power system analytical models at a scale sufficient to extrapolate the data beyond the laboratory level. Confidence in these models is important if industry is to design open and hybrid cycle power systems that meet the cost goals of the program. Achievement of these goals is dependent upon increasing the output of the power system and reducing the projected life cycle costs of major components. .

OTHER SOLAR ACTIVITIES

The FY 1988 budget request for the efforts in support of planned research activities is $8.4 million for operating expenses and $.6 million for capital equipment. These efforts include international, technology transfer, and resource assessment programs, the Solar Energy Research Institute, and program support and direction.

Technology transfer activities provide information to researchers, the general public, and industry concerning renewable energy. These activities include publications, professional seminars, industry workshops, and the Conservation and Renewable Energy Information and Referral Service. The FY 1988 budget request of $2.1 million for operating expenses will continue the technical and public information services at levels commensurate with solar research and development activities. The international solar energy program provides Federal organizations and industry with a vehicle for cooperative international trade development for renewable energy. DOE is responsible for chairing and providing financial support to a

Federal interagency committee, the Committee on Renewable Energy Commerce and Trade (CORECT), which is a forum where industry and the agencies can coordinate the use of existing resources and authorities to exploit export opportunities for the domestic solar energy industry. Additionally, funds are used to conduct a program managed by the Department of Commerce which cost shares, with industry, international exhibitions, special trade missions, and trade development services. The FY 1988 budget request is $0.523 million for operating expenses.

The FY 1988 budget request for the Solar Energy Research Institute (SERI) is $.620 million in capital equipment funds. The funds for SERI will improve the efficiency, safety, and security of this permanent DOE facility.

In FY 1988, funding for solar resource assessment activities will provide information regarding the distribution and spectral (wavelength) and temporal (time of day) variability of solar energy resources throughout the United States. The FY 1988 budget request for these activities is $0.7 million for operating and $.028 million for capital equipment.

Coordination of these activities and other ongoing research and development activities is an important part of the program support and direction functions. FY 1988 requests of $0.937 million for program support and $4.2 million for program direction funds will, among other things, provide technical and crosscutting studies of the various solar technologies, provide for updates to multi-year program plans, continue technical and programmatic dialogue with industry, and manage the diverse research activities in the national solar research program.

GEOTHERMAL ENERGY

The Geothermal Energy Program carries out research and development, in cooperation with industry, on an array of geothermal resource types (including geopressured, hydrothermal, hot dry rock, and magma) and on energy conversion technologies designed to define the technical and economic boundaries of this vast domestic energy supply resource. Program activities include applied research, technology development, and technology transfer efforts that will provide the basis for the timely introduction, by the private sector, of new concepts and products into the marketplace. The funding request for FY 1988 for the Geothermal Program is $15.9 million for operating expenses.

The purpose of the geopressured research program is to define the technical characteristics and recoverability of the large reservoir of hot brine and methane which lies beneath the U.S. Gulf Coast. The FY 1988 program includes experimental well flow testing, tests of the conversion of the combined energy content (thermal and chemical) to electricity, and supporting research on the dynamic response of geopressured reservoirs to production conditions, chemical constituents of the brine, and the possibility of land subsidence.

Hydrothermal research will expand the accessible resource base through an improved understanding of the processes for extraction and reinjection of geothermal fluids, new materials capable of withstanding high temperatures, high pressures, and highly corrosive environments, brine chemistry research leading to techniques to prevent plugging of wells and pipes, advanced power cycle technologies. In addition, researchers will analyze and synthesize data derived from the very high temperature geothermal reservoirs at the Salton Sea Scientific Drilling Project, and data pertaining to young andesitic volcanoes of the Pacific Northwest.

Hard rock penetration research will improve the technology and reduce the uncertainty of geothermal well drilling, which currently represents about half of the cost of geothermal power and which exceeds the cost of typical petroleum wells by factors of two to four due to the fact that geothermal wells are generally deeper, and encounter harder rock, higher temperatures, and more corrosive fluids than do oil and gas wells. Experimental program efforts include research on high-pressure water jets combined with rock cutters, mechanics of rock penetration, and drilling fluid loss control. Research also will be carried out to determine the depth and size of a large continental magma chamber, to evaluate alternative methods of energy conversion, and to develop materials and instrumentation capable of operations in the 1000 degree Celsius magma environment.

Hot dry rock research involves the evaluation of the properties of deep crystalline rock and the development of methods to extract geothermal heat from such resources. In FY 1988, the experimental extraction of heat from the large fractured reservoir at Fenton Hill, New Mexico will begin.

HYDROPOWER

Small-scale hydropower technology is nearing maturity, and the DOE program has made significant contributions to the technology base. Therefore, no funds are requested for FY 1988. Ongoing contracted analytical and technical support will begin to phase out. The remaining technology development and R&D projects then will be monitored by DOE personnel to ensure that technical goals and contractual and reporting requirements are met.

GEOTHERMAL RESOURCES DEVELOPMENT FUND

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guaranteeing loans for private sector development of several state-of-the-art facilities. The FY 1988 request is $.072 million in operating expenses which allows for monitoring outstanding loans.

ELECTRIC ENERGY SYSTEMS

Research in the Electric Energy Systems Program is designed to provide a technology base to enable the future electric energy network to operate more reliably and more economically while protecting health and safety and the Nation's security. The FY 1988 budget for the Electric Energy Systems research is $6.5 million.

Areas of investigation will continue to include determination of the biological health effects due to exposure to high voltage electric and magnetic fields; development of methods and options to ensure appropriate system reliability and the efficient use of resources during expansion of the Nation's future electric networks; development of techniques to provide electric power over a wide range of system conditions including both normal and emergency situations as well as improvements needed for national security; and development of new materials, advanced controls, and new design concepts to improve the efficiency of electric systems. The EES program continues to support research in three program areas Electric Fields Effects, Reliability R&D, and System Concepts.

In FY 1988 the Electric Field Effects research will continue to determine the impact of combined electric and magnetic fields on living tissue and whole bodies and initiate abnormal cell growth studies. The reliability R&D activities will focus on completing second level assessment of the impacts of an Electromagnetic Pulse (EMP) on the current electric power systems operations; and initiating studies on control and operating strategies to mitigate the effects of an EMP. Methods and strategies to operate complex, very large integrated electric power systems through improved system stability, operational and restoration techniques (on-line detection and recognition research) will also continue.

Systems concepts research will continue on interfacial phenomena in dielectric materials and the identification of toxic species in decomposed insulating gases will be completed. Research on control and protection concepts for electric systems with dispersed renewable sources will continue.

ENERGY STORAGE

The Energy Storage program conducts research to provide a technology base to develop advanced storage technologies. The FY 1988 budget for the Energy Storage research is $7.474 million in operating expenses and $.026 in capital equipment.

The program has moved toward a more basic and fundamental research agenda which will continue efforts on advanced energy storage systems to improve the efficiency of energy use and enhance the Nation's renewable energy resources. The program will permit international cooperation, thereby providing information exchange on the latest technology developments of advanced energy storage systems world-wide. The energy storage program ranges from fundamental research, to exploratory development of technical concepts, and includes work on new concepts, materials and components. The variety of technologies include batteries, fuel cells, thermal storage, and chemical/ hydrogen systems. This research provides an alternative for supplying future energy needs extending the useful life of existing central generating equipment, and increasing the economic attractiveness of renewable energy generating sources. As renewable sources of energy become even more competitive, and the penetration into the energy networks increases, the need for energy storage for these intermittent sources becomes more important. These technologies will be used in residential, commercial, industrial, transportation, and utility installations to promote more cost effective energy use.

In FY 1988 the Electrochemical Storage research activities will continue toward determining the structure, composition, and mode of formation of surface layers on battery electrodes; investigating the mass transfer rates of vertically oriented electrodes to improve electrode performance; and using new analytical tools, study the relationship between the kinetics of electrode processes and the atomic structure of the electrode surface. Other electrochemical research activities will include improving the production process of the beta" alumina electrolyte for the sodium/sulfur battery to yield a more reliable ceramic at a lower final cost; conducting performance tests of sodium/sulfur cells designed for electric vehicle applications; and evaluating and developing new sodium/sulfur, zinc/bromine cell designs for electric vehicle and load leveling applications which have improved durability and reliability. Thermal and Chemical Storage research will focus on evaluating and improving electrolytic cell materials and design characteristics of these cells for mid to high temperature electrolysis for the production of hydrogen; improving the technical and economic viability of diurnal to seasonal thermal energy storage for commercial and industrial application.

COOPERATIVE VENTURES

An innovative cooperative R&D approach has been carefully reviewed and expressions of interest are being solicited from industry. Partnerships in industry cooperative R&D ventures to support longer-term, high-risk, applied technology development of a generic or precompetitive nature can offer an effective method to leverage Federal moneys and increase program impact. This is intended to promote more effective technology transfer and to allow broader research support within current fiscal constraints. There appear to be good opportunities for cooperative R&D ventures in glazing materials, solid state power conditioning devices, and geothermal energy development. The precise choice of activities and allocations of funds will be influenced by formal industry proposals. Funding for cooperative R&D ventures has been proposed for later transmittal.

CONCLUSION

These renewable energy, electric energy system, and storage technologies show enormous potential for the future. Collectively, their potential applications are expected to ultimately make them highly attractive candidates for private sector development and deployment. These technologies promise increased energy supply diversity and should serve to promote increasing competition within the energy marketplace. Their development will also enhance the ability of the private sector to respond rapidly to unpredictable fluctuations in supply and price of fossil fuels.

The program presented for your review today represents a solid commitment to the continuing development of these technologies. We are confident that our proposals will increase understanding of the potential for virtually all of the most promising renewable energy options and will substantially contribute to the base of technical information required for informed decision making by industry and consumers.

Thank you for the opportunity to present our budget request.

BIOGRAPHICAL SKETCH

DONNA R. FITZPATRICK

Donna R. Fitzpatrick was nominated by President Reagan on July 31, 1985, and confirmed by the Senate on December 19, 1985. She was sworn in as Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy (DOE) on December 20, 1985. She had served as Acting Assistant Secretary since March 11, 1985, and as the Principal Deputy Assistant Secretary since January 1984.

In this position her responsibilities include management of research and development programs in energy efficiency and alternative fuels for industry, buildings, and vehicles. The programs in renewable energy resources involve research in active and passive solar, photovoltaic, wind, ocean thermal, geothermal, and biomass technologies. In addition, she administers federal grant programs for low-income home weatherization and energy efficiency improvements in schools and hospitals, and coordinates management of three of the five federal power marketing administrations.

In 1983, Miss Fitzpatrick served on a consultant team for the Secretary of Energy to conduct a general review of the Department's conservation and renewable energy programs, focusing on policy, program goals and priorities, budget levels, and new initiatives. In 1980, she served the Office of the President-elect as a member of the Transition Team for the National Science Foundation, reviewing national policy in basic science research, project efficiency, funding, and proposed legislation.

In her law practice, first with the Washington, D.C., firm of O'Connor and Hannan and then as a sole practitioner, Miss Fitzpatrick worked extensively on real estate development, helping to coordinate public and private interests and activities where Federal and District of Columbia involvement was required. This included work with local utilities and engineering planners to determine the legal, economic, and technical feasibility of various energy options, such as solar, cogeneration, and an on-site power generation and district heating system for large scale, high density residential and commercial uses.

Miss Fitzpatrick is also experienced in civil litigation, including administrative law and contracting issues.

Miss Fitzpatrick received a Bachelor's degree in physics cum laude from the American University in 1972. After teaching high school chemistry and mathematics, she entered law school and graduated from the National Law Center of George Washington University in 1980.

January 1986

PHOTOVOLTAICS

Senator JOHNSTON. All right. You are reducing the solar research by about 40 percent, and some programs in the research category will be cut even more. For example, wind energy would be cut by 50 percent and photovoltaics by 50 percent.

Tell me about those two technologies; what progress is being made and why the cuts?

Miss FITZPATRICK. Mr. Chairman, we have made significant progress in both of those technologies. For example in photovoltaics, about a decade ago, when the government became involved in photovoltaics resesarch, it cost about $100 per peak watt for a photovoltaic cell, and the cell had about a 6-percent conversion efficiency.

Today, you can buy modules for less than $5 per peak watt, and the conversion efficiencies available from commercial cells run around 13 percent. We have laboratory cells that run at least twice that efficiently, and we have as a program goal, which we expect to achieve in approximately 5 years, efficiencies over 30 percent up to as high as 35 percent, which industry could then develop at a system cost in the neighborhood of $1 to $2 per peak watt.

We think that we are making substantial progress. We also think that we have identified the remaining technical issues, especially involving cell design and the semiconductor materials themselves which will allow us to achieve that goal. Our budget is sufficient to support that research program.

ECONOMICS OF PHOTOVOLTAICS

Senator JOHNSTON. Well, at $5 a peak watt and 13-percent efficiency, how far is that from being able to compete economically with electricity off the grid?

Miss FITZPATRICK. Electricity off the grid; we should be able to get to about 6 cents a kilowatt-hour to be fully competitive, and we are now in the 25-cent range.

Senator JOHNSTON. It looks like if you could do that with your goal of $1 to $2 and 35 percent; it makes it highly competitive, doesn't it?

Miss FITZPATRICK. Yes; I think it does.

Senator JOHNSTON. When you get there, we are talking peak watts, if you were at $1 to $2 and 35 percent now, how would it compete with electricity off the grid?

Miss FITZPATRICK. If we achieve those initial costs and conversion efficiency, then we would be at approximately 6 cents per kilowatt-hour. The average cost in the United States for electricity today is between 6 and 7 cents a kilowatt-hour. So we would be competitive with virtually any other resource.

It is true that we are talking about peak watt. Photovoltaics, obviously, don't produce if the Sun isn't shining and, therefore, you would have to be thinking about at least an initial market of peaking power, power that would be available on hot sunny days basically. It happens to be today the most expensive power that an electric utility has to acquire, so 6 cents a kilowatt-hour is a very competitive price for peaking power.

Senator JOHNSTON. Do you foresee the day when a photovoltaic array would be on top of your house feeding electricity directly into your air-conditioning unit?

Miss FITZPATRICK. That is foreseeable.

Senator JOHNSTON. Converting from DC to AC, and all of that?

Miss FITZPATRICK. You might have to go through a converter, that is true, or you might have appliances that run on DC. The real key to making photovoltaics and certain of the other solar technologies fully integrated into the system would be efficient storage technology, which we are also working on, better batteries, for example.

Senator JOHNSTON. Listen, if you could have it for air conditioning, with the regular home, which is what the peak load is all over the South.

Miss FITZPATRICK. There are already designs and some attempts to install photovoltaic cells on automobile roofs to run air conditioners in the automobile. It is not at all a farout idea. I think that residential applications, or commercial applications, are certainly within the realm of possibility.

Senator JOHNSTON. How far away is that goal?

Miss FITZPATRICK. We hope, in our research program, working with industry, and a great deal of this is cost shared up to 50 percent with industry, to achieve these efficiencies that I was speaking of in the early to mid-1990's.

Senator JOHNSTON. The photovoltaic industry is on the ropes financially, isn't it?

Miss FITZPATRICK. It is going through difficult times, that is true. It is suffering what the rest of the energy industry is suffering. Reduced prices make it difficult for new technologies to compete, that is true.

Senator JOHNSTON. If we are right around the corner, 5 years or less, from having photovoltaics compete with the grid, why are there not big investments being made by both DOE and the private sector in this technology?

Miss FITZPATRICK. I think we are making the investments that need to be made to solve the remaining research issues. There is a steady level of investment by the private sector in becoming more familiar with these systems.

There are some 40 utilities across the country running more than 70 photovoltaic systems. They are small scale. They are becoming familiar with how they behave. They are training their people in how they operate, and they are keeping very close tabs on the development of technology, which is moving very fast. It is hard to put up a system today that isn't obsolete before you get it up because of the rapid advancement in the field.

I think that the industry is doing just about what it ought to be doing. It is moving steadily and deliberately to increase its own understanding of how the systems work and to be prepared when the capacity demand is there to make investments that will be substantial.

There is, generally, a surplus of generating capacity in the country, which we expect to run out within the next 10 years, but people are not inclined to buy generating capacity before they need it.

Senator JOHNSTON. Something just doesn't sound right here to me. You say that we are 5 years away from making photovoltaics competitive at today's rates with power from the grid.

Miss FITZPATRICK. Competitive for peaking power.

Senator JOHNSTON. Competitive on a hot afternoon, and this is considering what life cycle on the photovoltaic equipment?

Miss FITZPATRICK. We are aiming at a 30-year system life.

Senator JOHNSTON. A 30-year system life.

Miss FITZPATRICK. Right.

Senator JOHNSTON. Maybe that is why; things don't usually last for 30 years.

Miss FITZPATRICK. An ordinary electric generating plant certainly should. A coal-fired plant, for example, should last that long.

Senator JOHNSTON. But the array you have up on your roof won't last that long. I am thinking of miniaturization.

Miss FITZPATRICK. You are correct. What is presently available today is not warranted for 30 years. A 10-year warranty would be a good one.

Senator JOHNSTON. In any event, you say that you have plenty of money in this budget, though reduced by 50 percent for photovoltaics, to push this technology to its optimum level?

Miss FITZPATRICK. Let me say, not plenty, but I think we have sufficient funding. I think that it is adequate to do the job. It is a lean and tight budget, but I think it is adequate.

WIND ENERGY RESEARCH

Senator JOHNSTON. On wind energy, I have been around Palm Springs and that area of California. Where is that area?

Miss FITZPATRICK. Altamont Pass above Livermore.

Senator JOHNSTON. I have seen so many of those wind machines that are lying fallow, vacant, not turning, whatever the word is, at rest. Is this an indication that it doesn't work?

Miss FITZPATRICK. No, Senator, I think not. I don't know how recently you were there, at Altamont Pass. The wind turbines that have been put up within the last couple of years are certainly significantly improved over those that were installed 5 to 7 years ago.

They now have improved the technology of the wind turbine itself plus the ability to manage wind turbines, to control them by computer, to establish management methods of keeping them well maintained and quickly repaired whenever anything might go wrong. As a result, we now have much higher capacity factors on the wind farms that are operating in the Altamont Pass, and that has become a very attractive way of generating energy and, in that particular area, a resource that is almost exactly matched to the demand curve in that area.

Senator JOHNSTON. Private enterprise is not going to be rushing out to build these wind turbines, though, are they?

Miss FITZPATRICK. Those farms are private enterprise. There are new wind farms going up in such places as Hawaii.

Senator JOHNSTON. Without government subsidized?

Miss FITZPATRICK. Those are private wind farms.

Senator JOHNSTON. Not subsidized.

Miss FITZPATRICK. Nothing from the Department of Energy. They have some tax investment. There are still some tax credits available.

Senator JOHNSTON. What is the degree of tax subsidy?

Miss FITZPATRICK. I am sorry, I am corrected. The wind tax credit expired at the end of 1985, so those are nontax subsidized.

Senator JOHNSTON. Those in place, though. They are not building any new ones.

Miss FITZPATRICK. They are in place and operating. They are very new. They have just been put in since the tax.

Senator JOHNSTON. They were paid for with tax subsidy, and the wind is free. What I am talking about, are you building any new ones in private enterprise without subsidy?

Miss FITZPATRICK. Yes; the industry is continuing to install wind turbines.

Senator JOHNSTON. Without subsidy.

Miss FITZPATRICK. Without tax credits; that is correct.

PHOTOVOLTAIC CELL EFFICIENCY

Senator JOHNSTON. What is the technology by which you would get 35-percent efficiency?

Miss FITZPATRICK. That would be a multijunction cell. That is a cell that is made up of two or more kinds of separate materials, each of which would respond to a different area of the solar spectrum.

Senator JOHNSTON. Sort of like a plywood.

Miss FITZPATRICK. It would look like a sandwich; yes.

Senator JOHNSTON. They used to say that in order to be competitive with photovoltaics, you would have to be able to make your cell almost like being painted on. Can you paint on these layers, without having to grow those crystals?

Miss FITZPATRICK. That is true; one of the big cost factors was having to grow a very good crystal, and then handle it, slice into thin pieces, and install the conductors.

The latest technology, and part of our research program, is to reduce the production cost by using such things as you described, a thin film instead of a single crystal, and that can be automated. There has been a considerable amount of success in various ways of growing those thin films.

Senator JOHNSTON. Thank you very much, indeed, Miss Fitzpatrick. We appreciate your testimony. This is a very interesting area. I don't think that we will ever get photovoltaics to compete with central power in the sense of central power generator, but I think that it may well be a very useful augmentation of peaking power, because the peak in demand does come at the peak of the sunshine, and the highest electricity demand, of course, is air conditioning, at least in the southern states.

I hope that we are doing enough in this area to reach that goal when you say we are.

Miss FITZPATRICK. Thank you, Mr. Chairman.

OFFICE OF ENERGY RESEARCH

STATEMENT OF DR ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH

Senator JOHNSTON. Next we are pleased to welcome Dr. Trivelpiece.

We are very sad and disappointed, Dr. Trivelpiece, that you will be leaving the Department. We consider you to be the creme de la creme of scientists in the government. We are going to miss your very wise counsel and guidance in scientific matters, but at least we have you here for a while. I welcome you to the committee.

Dr. TRIVELPIECE. Thank you, Mr. Chairman, that is very flattering. I appreciate the opportunity to appear before you this year, and it is with some sadness that I am leaving the Department of Energy. This has been a very interesting 6 years. I appreciate the reception that this committee and the staff have given me during that period of time. It has been a very useful working relationship from my side, and I appreciate it from your side. Thank you.

I have a large collection of things and I will try to mention them briefly.

HIGH ENERGY PHYSICS PROGRAM

First, I want to mention high-energy physics. This year has seen the initiation of the commissioning of the Tevatron accelerator at Fermi Laboratory, which has nearly reached its goal, producing 900 GeV protons and antiprotons. The collisions are taking place; the detectors work. They have it up and running. It is a remarkable accomplishment.

The same thing is true with the Stanford Linear Collider. It is a 50 GeV electron/positron collider. Its construction is completed and it is in the process of being commissioned now. Its early operation should be in the next month or so.

These two facilities, in a sense, provide upgrades that are needed by the high-energy physics community and they will remain state-of-the-art for about 10 years. By that time, it is our hope, of course, that the Superconducting Super Collider has been built and is on line, because it is going to take about 10 years to bring it up. So the two situations are reasonably well matched.

The thing that I want to call your attention to is the book that is in front of you, the red book like this one. I like to brag about these programs from time to time, but it is quite nice when somebody else brags about them for you.

[The information follows:]

Loma Linda University

Vice President for Medical Affairs
Loma Linda, California 92350
714/824-4459

Loma Linda Proton Therapy Facility

Loma Linda University Medical Center is sponsoring the design and construction of the first particle accelerator built specifically for therapy with proton beams. This new step is most appropriate for an Institution whose campus centerpiece is The Good Samaritan and whose motto is "To Make Man Whole." We will soon be able to treat patients with precision, compassion, and dignity with the new facility so that health and life can be restored without the effects of cancer treatment resulting in a debilitated, disfigured and disheartened person. The principles and usefulness of proton-beam therapy have been demonstrated by the pioneering work at Harvard and Berkeley and we are expanding the treatment to all body sites and to many more patients.

Loma Linda University and Medical Center, located 60 miles east of Los Angeles, is a leader in the Adventist Hospital Systems and Services worldwide and is one of the largest private teaching hospitals in the western United States. Loma Linda physicians and scientists began developing the particle-accelerator program in the early 1970's as a very large extension of their existing regional, national, and international service to cancer patients.

The Institution is funding the construction of the high-tech, highly-humane patient-treatment center and will offer the facility for patient care nationwide, as well as train other patient treatment leaders in the use of proton-beam technology. The University and Medical Center expect to offer patients the benefit of this new treatment method in early 1989.

David B. Hinshaw, M.D.
Vice President for Medical Affairs

PROTON THERAPY AND THE CONTROL OF CANCER

We stand at the threshold of an important breakthrough for the control of cancer, and thus the relief of suffering and the betterment of life.

Promising develoments are taking place concerning the control of cancer through particle-beam irradiation or proton therapy.

The use of protons in cancer therapy was first proposed in 1946, but has been deferred, except for highly successful special treatment, until the more recent development of sophisticated electronic imaging techniques.

With the availability and widespread use of Computed Tomography devices (CAT scanners) and Magnetic Resonance Imaging devices (MRI's) to determine precise tumor location and size, the use of proton therapy in the treatment of these tumors becomes a viable treatment method.

Through the efforts of Loma Linda University Medical Center in California and Fermi National Accelerator Laboratory in Illinois, a proton accelerator specifically designed and constructed for medical service will begin treating patients in Loma Linda in the spring of 1989.

Proton Therapy: A Viable New Medical Treatment

Conventional radiation can control cancer by killing cancerous cells, providing the absorbed dose is sufficient. But, because of the inability to selectively irradiate the cancer, normal tissues receive a similar dose and are damaged. As a consequence, a less than optimal total dose is frequently used in order to reduce unacceptable normal tissue damage. This results in a level of local disease control that varies for different types, stage, and location of cancer.

tance at the end of the range, called the Bragg peak after its discoverer. Thus the cell-killing effects of radiation can be localized. By careful choice of the energy and by screening the sides, the physician can achieve a good kill rate of diseased cells, while largely sparing nearby healthy tissue. This is especially important when a tumor is located close to vital organs, like the heart or spine, that cannot tolerate the full dose of radiation.

Controlled Dose Distribution: Key to Control of Tumors

The failure to effect local control of tumors is a fatal problem in over 100,000 patients each year in the United States. One approach to improve the incidence of local disease control is to reduce the dose delivered to surrounding normal tissues, while increasing the tumor dose. Heavy charged particles such as protons have very significant advantages for this approach. The dose distribution along the range of a proton beam will allow the therapist to reduce the dose delivered to normal tissues by a factor of 2 to 5.

Charged particles, such as protons of a specific energy, have a definite range in matter. They lose energy by collisions with atoms, and finally stop, all within a few millimeters of one depth. This depth depends only on the energy of the ions. What is even more important, most of the energy is deposited within a small dis-

Concentration of Dose in the Tumor Decreases Damage to Healthy Tissue

The Bragg peak for monenergetic proton beams is only a few millimeters wide; this is much smaller than most radiation therapy target volumes. But the peak can be spread to any desired depth by energy modulation. The proton synchrotron designed for the Loma Linda University Medical Center facility has continuously variable energy corresponding to a tissue range variation from 3 cm to 38 cm, the full depth of a large body. Thus, by varying the energy and the number of protons accelerated, the Bragg peak can be shaped to deliver homogeneous doses of radiation to irregularly-shaped three-dimensional volumes.

Ocular Melanomas

The concentration of dose is particularly important in the treatment of tumor growths inside the eye (ocular melanomas). Proton irradiation has become the treatment of choice for this disease because it spares the sensitive tissue of the eye and the optic nerve, thus preserving the patient's vision. The treatment before protons were available was limited to removal of the eye, with resulting loss of vision and disfigurement. Proton treatment is successful in 95% of these cases, whereas surgical procedures have been successful in only 60% of the cases treated.

First Hospital-Based Treatment Facility

The Loma Linda University Medical Center proton treatment center now being developed will utilize a dedicated variable-energy proton synchrotron to supply beams to multiple treatment rooms.

The accelerator is being designed and built at Fermi National Laboratory. The entire facility is being designed to utilize state-of-the-art electronic advances, to minimize human effort and give increased precision and efficiency of treatment planning, beam transport, and patient positioning.

There are multiple factors that justify the further expansion of proton therapy to a large hospital-based effort in order to establish a full clinical facility:

> The absorption characteristics of protons in tissue provide the radiation oncologist with a practical modality to control the dose delivered to a cancer.
>
> The technology exists to design and build a reliable accelerator and sophisticated beam delivery system that will allow precise deposition of a high dose in an irregularly-shaped volume in any anatomical site inexpensively.

New Technology opens the Door to Proton Therapy

The treatment of malignant diseases with high-energy ion beams has been confined until this time to particular disease sites, such as the head. Until recently, there was a lack of sufficiently precise diagnostic capability to define the target volume containing the malignant areas so that one can successfully utilize the localization capability of charged-particle beams. The availability and widespread use of Computed Tomography devices (CAT scanners) and Magnetic Resonance Imaging devices (MRI's) have now made it possible for physicians to define the tumor volumes with such accuracy that three-dimensional localizaiton of the radiation effects is not only practical, but is mandated for future treatment of many cancer patients.

Physics Research: Instrumental in Medical Therapy

Proton and heavy-ion accelerators, all originally built for physics research, have been used for medical therapy for more than a quarter of a century. They have been somewhat limited because the beam energies are not necessarily correct for therapy and because the energy cannot be varied easily. In spite of the limitations, these accelerators have been highly successful in the control of tumors of the head and neck, eye melanomas, prostate and pelvic tumors and non-cancerous diseases such as Cushing's disease, arteriovenal malformations, and others.

Ernest Lawrence, the inventor of the first modern accelerator, and his brother John Lawrence, a physician, treated a few cancer patients (including their mother) with neutrons in the 1930's. Robert Wilson, who had been a Ph.D. student of Ernest Lawrence's, first proposed the use of protons in a paper in 1946. He made this treatment one of the goals of the cyclotron he was then building at Harvard. This accelerator was used to treat cancer patients beginning in 1959, and has treated more patients than any other accelerator. Many pioneering innovations have been introduced by the physicians and physicists of the Harvard Cyclotron Laboratory and Massachusetts General Hospital.

Work has also continued in Ernest Lawrence's laboratory at the University of California in Berkeley. Here the emphasis has been on ions heavier than protons. Heavier-ion beams can be even more localized than proton beams, but heavier-ion accelerators are substantially larger and more costly to build than proton accelerators, since the energy per nucleon of the heavy-ion beams must be the same as the proton energy for equal penetration in tissue.

Proton therapy has also been used in Uppsala, Sweden, and at three laboratories in the USSR, again with good results. All these accelerators were originally built for scientific research.

Clinical work at Massachusetts General Hospital and at the University of California in Berkeley has been supported by the National Institutes of Health.

Fermilab: Its Role in Proton Therapy Development in U.S.

Robert Wilson founded Fermilab and led it through its first decade. He maintained his long-standing interest in proton therapy, and in the early 1970's, he and some of his colleagues proposed to use the Fermilab linear accelerator for therapy when it was not in use as an injector. But, the ability to make use of the localized dose of protons depends on knowing the location of the tumor. The technology to perform this localization was not fully developed at that time, and the physicians collaborating with Fermilab urged them to produce neutrons with the proton beam and to perform therapy with neutrons. Neutrons are somewhat more efficient than protons or electrons at killing cells, but do not have the great advantages of protons in localizing the dose. The Fermilab Neutron Therapy Facility has been in operation for more than ten years and has treated more than 1,600 patients.

In the intervening years, proton therapy has proceeded at Harvard, and CAT scanning and MRI have come to fruition. With their use, it is possible to take full advantage of the tight control of the irradiated site that is possible with protons. It is now advantageous to build an accelerator and facility specifically for the treatment of disease with proton beams in a hospital setting.

In January 1985, a group interested in studying the design of potential proton accelerators, facilities, and clinical trials met at Fermilab in Batavia, Illinois for the first in a series of meetings. In these meetings, the group, which came to call itself the Proton Therapy Cooperative Group (PTCOG), proposed and discussed a variety of machine designs and beam-delivery systems. One outgrowth of the PTCOG meetings has been an agreement between Loma Linda University and Fermilab, whereby Fermilab will design and fabricate a 70 to 250 MeV proton synchrotron and assist in the design and procurement of a beam transport and delivery system for installation at Loma Linda University Medical Center.

Fermilab is owned by the United States Department of Energy and operated by Universities Research Association, Inc.

New Radiation Oncology Center in Progress at Loma Linda University Medical Center

The new radiation oncology center will be contained within a new building located to provide contiguous space with existing conventional treatment facilities. The treatment floor of the new structure will house the proton synchrotron, three proton treatment rooms with isocentric gantries, one treatment room with a fixed horizontal beam, and a room dedicated to radiobiology and physics research. Support space will be centered about a treatment-planning complex to include a patient immobilization laboratory, two CAT scanners and multiple treatment-planning computer work stations.

Patient waiting, examination and treatment preparation rooms will be provided, as well as staff offices, conference rooms and accelerator technical support facilities. Two operating room suites will be adjacent to the isocentric rooms to provide intraoperative proton beam treatment.

The proton accelerator designed for this facility is a synchrotron. It is a ring approximately 20 feet in diameter. Protons are bent around the ring by eight electromagnets and accelerated as they circulate by a radiofrequency voltage across a gap in a cavity.

The beam is accelerated to full energy in a half second. At that time, it is extracted slowly from the accelerator and sent down a beam line to the treatment rooms. The resulting "spill" can last up to one second. There is then a period of a half second for the accelerator to be reset for injection of more beam. The total cycle time is thus 2 seconds.

New Facility: Increased Availability to Treat Patients

TREATMENT ROOMS

The proton therapy accelerator is being designed as a full-scale clinical facility with three isocentric gantries, each capable of bringing the beam to the patient from any angle, and one fixed-beam room for particular treatments, such as the eye, and for producing very large fields of irradiation. Each of the four treatment beams will contain all the equipment needed to align the patient precisely with respect to the beam, to spread the beam to the right size for each tumor and to absorb beams that would strike healthy tissue.

The patient will be on a couch or sit in a chair, as appropriate for his or her treatment. The alignment and verification, controlled from a local control room just outside the treatment room, will take most of the time. The actual beam time will be less than a minute for most treatments.

SUPPORT FACILITIES

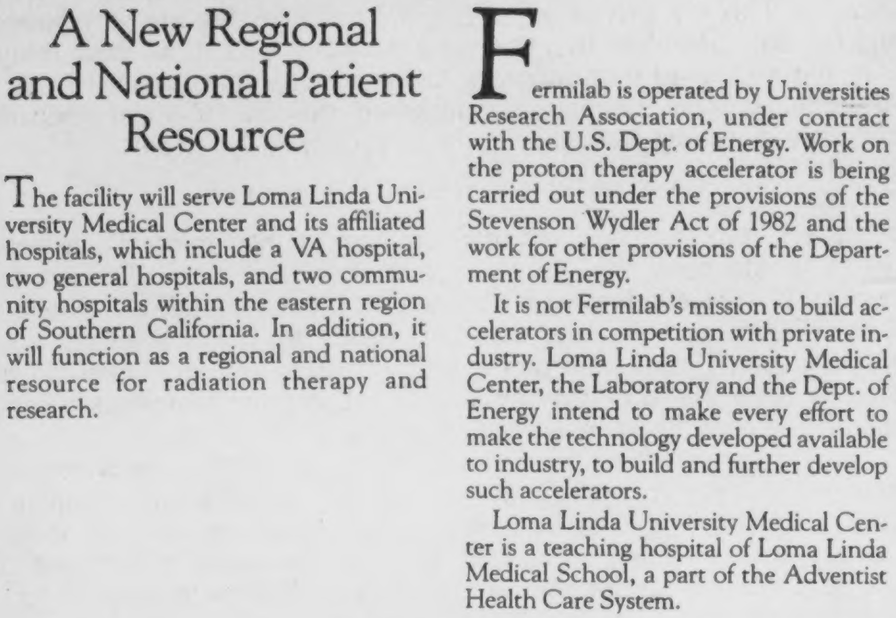
A comprehensive support facility is being built as part of the proton therapy system. It will contain the examining and planning rooms and all the modern equipment needed for diagnosis and treatment planning.

The facility will include an operating room so that radiation treatment can be done during an operation.

SAFETY

The entire facility is being built underground to provide natural radiation shielding. Thick concrete walls are being provided within the building to shield all beam areas. The accelerator and all equipment are designed for fail-safe interlocks to guarantee electrical and radiation safety. The proton therapy facility will be a safe system, providing radiation only when it is desired, in an environment that is safe for patients and hospital staff.

In the United States, the Loma Linda University facility described here will begin operation in 1989. Other medical centers are also developing plans for similar facilities. The time for such a venture is right, because the advanced technology is available and the understanding of radiation and tumor biology is rapidly developing.



A New Regional and National Patient Resource

The facility will serve Loma Linda University Medical Center and its affiliated hospitals, which include a VA hospital, two general hospitals, and two community hospitals within the eastern region of Southern California. In addition, it will function as a regional and national resource for radiation therapy and research.

Fermilab is operated by Universities Research Association, under contract with the U.S. Dept. of Energy. Work on the proton therapy accelerator is being carried out under the provisions of the Stevenson Wydler Act of 1982 and the work for other provisions of the Department of Energy.

It is not Fermilab's mission to build accelerators in competition with private industry. Loma Linda University Medical Center, the Laboratory and the Dept. of Energy intend to make every effort to make the technology developed available to industry, to build and further develop such accelerators.

Loma Linda University Medical Center is a teaching hospital of Loma Linda Medical School, a part of the Adventist Health Care System.

PROTON CANCER THERAPY

Fermi National Laboratory is helping the Loma Linda Hospital in California with the design of an accelerator which will be used for proton cancer therapy. The arrangement is that the laboratory will help with the technology of getting that built, and at the same time Loma Linda will involve a private contractor, so that at the end of this period of time, the facility is built and the technology has been transferred to the private sector, and there is the proton cancer therapy hospital arrangement available at Loma Linda.

Senator Johnston. Where is Loma Linda?

Dr. Trivelpiece. It is in California.

Senator Johnston. Where in California?

Dr. Trivelpiece. Southern California.

Senator Johnston. You have a proton machine in connection with the Berkeley Lab.

Dr. Trivelpiece. There is one at Berkeley.

Senator Johnston. I have seen that one at Berkeley. It is ions that they use there.

Dr. Trivelpiece. This is the same therapy, ocular melanoma, and the vascularizations in the brain, which are life threatening to some young people from a genetic defect. Those can both be cured with very high efficiency by the proton beams.

In the past, this has been done as kind of a parasitic operation on the operation of the accelerator at Berkeley, as well as Fermi Lab and other places. In this case, Loma Linda is building a hospital unit that is dedicated exclusively to that kind of therapy, and not for research. It is a separate event.

The technology transfer is taking place. This won't be part of the laboratory. This is a private sector hospital initiative. We are very pleased, and the little pamphlet that they have prepared talks to all these things.

In the nuclear physics program, the accelerator that is called Atlas, at Argonne National Laboratory, pioneered the use of superconducting materials in a radio frequency cavity to accelerate the beams.

SUPERCONDUCTING MATERIALS RESEARCH

Senator JOHNSTON. Let me interrupt you at that point. There was a report in the news the other day that there had been a new breakthrough in superconducting materials, that these materials can superconduct at 100 degrees warmer than they have had. It has been just about absolute zero, I think, and now it is 100 degrees warmer. They said that there is hope that they may be able to get to room temperature superconducting capacity at some time. Was that a correct report?

Dr. TRIVELPIECE. Yes; it is correct. It is an exciting development. I have yet to have an opportunity to read any scientific papers on it, or have a full briefing, but from what I have read and learned about it casually, it is obviously an exciting and important development and one that several DOE laboratories are involved in. We try to keep on top of it as best we can.

SUPERCONDUCTING SUPER COLLIDER (SSC)

Senator JOHNSTON. Wouldn't this impact the cost of the SSC?

Dr. TRIVELPIECE. I doubt it, although that is a thing that should certainly be kept in mind. Consider that if the SSC proceeds on the schedule that we are currently anticipating, the need to buy the superconducting materials for the magnets will occur as early as next year or the year after next.

I find it hard to believe that something like a discovery of this sort could go from a laboratory discovery to a technology capable of producing thousands of miles of wire on a commercial basis and that such wire could be fabricated into cable, the cable fabricated into magnets, and the necessary reliability studies done on these that would be comparable to the 15 to 20 years of work that have gone into what makes the Fermi Lab accelerator work now.

It would be a very risky situation to try to introduce a new technology like that at this time. It may well be, sometime from now, that these superconductors will be available on a commercial basis. It is entirely possible that the process of converting those from a laboratory demonstration to a mature technology can occur more rapidly than I expect. But my suspicion is that it will not occur, and we are not currently planning on it.

Senator JOHNSTON. I have heard it said that this could be a breakthrough similar to the transistor in importance.

Dr. TRIVELPIECE. Yes; I think that this is quite correct.

Senator JOHNSTON. How soon is the 100-degree reduction, that kind of breakthrough, or do you have to come down to room temperature?

Dr. TRIVELPIECE. No; I think liquid nitrogen temperature at 77 degrees above absolute zero is already an outstanding achievement. The cost of liquifying helium and the low-heat capacity that it has, makes operating present superconductors a very expensive proposition, although less than operating regular conductor-type magnets.

To operate at liquid nitrogen temperature is much easier. The cost of producing liquid nitrogen is quite low. I think that it used to be like the cost of milk, but I forget exactly whether that is true now or not. The ease of handling it, the mechanical process of handling liquid nitrogen, is just so much simpler than that of helium.

Senator JOHNSTON. I hope that we will keep that technology and not give it to the Japanese before we develop it ourselves.

Dr. TRIVELPIECE. I expect that this is a problem, because part of this was discovered in Switzerland at the IBM Laboratory. Most people around the world have already duplicated these results.

I was just talking to some Russians the day before yesterday in Vienna, and they have already duplicated the results there. So it doesn't take very long for people to figure out that somebody is working in an area, that they have made a discovery, and know approximately the methods by which they were going about this. They just simply set out to duplicate it, and they already have.

Senator JOHNSTON. Please proceed.

NUCLEAR PHYSICS PROGRAM

Dr. TRIVELPIECE. When I mentioned superconductivity, I was doing so in conjunction with the Atlas accelerator, which is at Argonne National Laboratory. Its radio frequency cavities are coated with superconducting material, which greatly improves the operation of the accelerator, and so on.

That technology was transferred down to the Continuous Electron Beam Accelerator Facility [CEBAF], which you are quite familiar with, perhaps both of you are. Superconducting cavities have made a great improvement in CEBAF, and it will reduce its cost of operation, and improve its quality and the energy that you can achieve within the cost envelope that was already planned for.

The construction for CEBAF started down there a few weeks ago. We had a small groundbreaking ceremony. The CEBAF construction is underway, and that is an accomplishment in nuclear physics this year.

MAGNETIC FUSION PROGRAM

In magnetic fusion, this last year has seen the Tokamak reactor at Princeton meet its original design goals. It has produced plasmas of the temperature and density that are thought to be needed in order to produce reactor grade plasmas.

We did, because of some of the budgetary stringencies over the last few years, modify that program in such a way that the introduction of tritium didn't take place as early as we would hope, but that is still planned to be done. The one remaining goal of producing a substantial quantity of neutrons in that machine is scheduled in the near future, next year, and the year after next.

COMPACT IGNITION TOKAMAK

Based on that success, then, we are proposing to build a device that follows on from that, which is a Compact Ignition Tokamak. The difference between what TFTR does and what is needed to be done next, I think I have used the analogy before, is like shining a blow torch on a log. As long as you keep the blow torch shining on the log, the log will continue to burn, but if you take it away, it stops. If you have three logs, and the fire gets started, the fire will be sustained.

The present generation of Tokamak is like one log that you have to keep the heat being poured into it in order to keep it burning. But, if you can get ignition to take place by having a strong magnetic field and a slightly larger volume, then the product of the tritium reaction, the alpha particles, the heat that they generate or release, is trapped inside the plasma and it can ignite.

So, the next technical or scientific step that is needed in the fusion program is to demonstrate ignition, and this device should do that. Beyond that, then, there is the need to do something in the way of an engineering test reactor.

Senator JOHNSTON. Have we met the goals for ignition? Three years ago, what was the date for ignition?

Dr. TRIVELPIECE. I don't know that there has ever been a goal for ignition. The Tokamak Fusion Test Reactor, which was started in 1974 and 1975, has met its goal in terms of the temperature to be created, the density, and the time of containment. But it hasn't completed one of its goals, which was to demonstrate that it could produce about 10 megaJoules of neutron through fusion reaction.

In order to do that, you have to introduce tritium, and in order to introduce tritium, there has to be certain equipment installed on it to handle the radioactive tritium and be able to dispose of it. Because of the budget stringencies, we didn't put that equipment in, but we have concentrated on doing experiments to demonstrate the characteristics of plasma, rather than demonstrating the ability to produce the neutrons.

I believe that it is possible to do so, to produce that quantity of neutrons now. Implicitly, it is available, but it is just that it hasn't been done. But the goals that were established for that device have been met, and now additional information about the physics of the plasmas is still being acquired as part of the ongoing process of learning.

COMPETING FUSION TECHNOLOGIES

Senator JOHNSTON. How many separate fusion processes are we now pursuing?

Dr. TRIVELPIECE. I am not sure exactly what you mean by your question. One is the Tokamak. The other is the magnetic mirror program at Livermore, the MFTF–B project that is currently mothballed. The budgetary realities of the last couple of years have forced us to put that into a standdown mode. It could be operated at some time in the future.

Having to pick between winners and losers, in effect, has forced us into, for the time being, concentrating on the Tokamak device since that is the one that is producing the results that are the most promising.

Senator JOHNSTON. Don't we have two different Tokamak technologies that we are pursuing?

Dr. TRIVELPIECE. There are different experiments doing other related supporting work. One of them is the Doublet-III at GA Technologies. There is also a Tokamak device, the Advanced Tokamak Facility, that is being assembled at Oak Ridge. But all of these fit into the overall program of solving different scientific and technical problems associated with confined plasmas.

Senator JOHNSTON. Then at some point, we have to go to a bigger machine.

INTERNATIONAL COLLABORATION

Dr. TRIVELPIECE. Yes; the estimates for a device beyond the Compact Ignition Tokamak is probably $4 billion. I know that you, and other members, as well as people in the administration, suggested that that is the stage at which international collaboration and cooperation is certainly called for.

Over the last few years, I have met with a group in an economic summit process to talk about the cooperation on such a device. President Reagan and General Secretary Gorbachev mentioned this at their Geneva Summit in 1985, and that has stimulated some activity which led to a lot of internal debate within our own government, and other governments, on what we should do, and whether we should do it.

I am pleased to say that I literally just came back yesterday from Vienna, from a meeting in which the United States, the Soviet Union, Japan, and the European Communities, collectively, as a four-party arrangement, discussed, in effect, the terms of reference that we will use to go through the development of a conceptual design report, which should take something like 2 or 3 years to complete.

The conceptual design report will then talk about this next device, what we call the Engineering Test Reactor. How much does it cost? How long does it take? What does it consist of? All of the general kinds of things that you would do for any project, but instead of doing this exclusively within the United States, or in other countries, we are going to do it on a joint basis.

Each country will contribute probably 50 man-years per year of effort to this joint discipline activity, leading to a conceptual design report. This is being done under the auspices of the IAEA.

Senator JOHNSTON. When will we be ready to start serious negotiating internationally on sharing the costs?

Dr. TRIVELPIECE. I think that the serious negotiations should take place only after there is something to negotiate over. In other words, we shouldn't buy a pig in a poke.

Senator JOHNSTON. After the conceptual design report.

Dr. TRIVELPIECE. When the conceptual design report is available, I think the United States should take a look at it and decide whether or not it believes that it is in its best interest to participate in that and build it, and at that time seek the appropriate cost-sharing arrangements.

It will either be such that, yes, everybody wants to do this, or, no, nobody wants to do it. The economies, the politics, and so on, may be different at that point. But this permits the decision to be made on a sound basis, rather than to be made kind of just looking down the road and say, yes, we ought to do it.

That has gone very well. A year ago, I would have been quite pessimistic about the prospects of those four parties—the United States, Japan, the Soviet Union, and the European Communities—sitting down, talking about beginning a process seriously leading to a conceptual design report. Unless something has gone wrong since I left Vienna, it looks like that is exactly what is going to happen.

Senator JOHNSTON. Would you give us your best guess, if things go right—if we finish the conceptual design report, fund it, build the machine, it is successful, then build the follow-on—how far are we at optimum or what do we expect from being able to build our first fusion Tokamak to generate energy, if it works in terms of economics, how long until it would be before we could expect a substantial payoff economically toward the energy equation?

Dr. TRIVELPIECE. It depends exactly on what you demand of it, and the degree to which you want to force feed it. Obviously, infinite money won't make all that happen tomorrow. At the present pace of activity, which seems to be well matched to about the pace at which understanding and accommodation to understanding can be made, it is certainly going to take at least 2 or 3 years to get this conceptual design report.

The device which is being discussed, if it is built on an international basis, is going to take 10 years to build. It is going to take several years to operate and obtain the understanding for it. You can clearly see a period of 15 to 20 years before you are at the end of that process in which not only the scientific and the technical, but some of the engineering information is available.

Depending on whether or not you insist on going all the way to making electricity and trying to compete with a mature nuclear power industry, or you talk about the use of neutrons to make various fissile atoms for use in existing light water plants, that could be any period from a few years beyond an engineering test reactor operation to another 15 or 20 years. That depends greatly on the engineering and the economics that are available.

As you are aware, the report of the Secretary of Energy to the President recently indicates that there are still shortages and that we are embedded in a world within which the pressure to introduce some technology will either be more intense or less intense, depending on other outcomes.

Senator JOHNSTON. From the information that is available on this, I concluded, although it wasn't a permanent conclusion because we are a long way from making that conclusion, I concluded that this would probably have its greatest use as a breeder for making these various fissile materials that you are speaking of.

Such a judgment is very premature at this point, but wouldn't you share that view tentatively?

Dr. TRIVELPIECE. I think that it is the more likely. Recently, the National Academy of Sciences has completed a study, and I don't know if the report has been made public yet, but they have talked about this prospect. When that report is available, I will make it available to the committee.

SUPERCONDUCTING SUPER COLLIDER

Senator JOHNSTON. Let's talk about the Superconducting Super Collider.

Dr. TRIVELPIECE. All right. Do you have a specific question or would you like me to start? [Laughter.]

Do you have a couple of hours?

Senator JOHNSTON. It is a vitally interesting subject to me.

Senator MCCLURE. You might start out with why are you going to build it in Idaho instead of anywhere else? [Laughter.]

Senator JOHNSTON. Senator McClure and I both said the other day, in one of our hearings, that you shouldn't pick your place before you get it authorized. [Laughter.]

Dr. TRIVELPIECE. The administration agrees with that. We have tried to lay out a strategy whereby we hope this will occur. As you know, we have asked for approximately $10 million in construction funds this year, which should be sufficient to get it approved. Obviously, next year, it is substantially more money for the long leadtime construction items.

SITE SELECTION SCHEDULE

The schedule that has been laid out, beginning with the President's decision on January 30, involves April 1 as being the date on which we hope to have the invitation for site proposals delivered to the Governors of the various states and available to all interested parties. Then a 4-month interval is allowed for preparation of the proposals.

The Department needs a little time to review these before we send them to the National Academies of Science and Engineering. Our review will be a very cursory or prima facie review to see if the various requirements have been met so that the proposals that we send to the Academy are, in fact, reviewable.

The Academy then will take until January 1988 to review these against the criteria that have been made available to it by the Department. The Academy will return to the Department five or six, or whatever it believes to be the most excellent. Then the Department will need several months to go through the details of what has been proposed, to verify the costs.

Whatever a state said it has in the way of land, or electricity, or water, we can't be put in the position of having to take at face value what their word is in the proposal. DOE teams will go out and verify the geology, and drill holes, and things like that, whatever is needed to be done to analyze the costs.

Then, through what is called the Energy Systems Acquisition Advisory Board, which is chaired by the Under Secretary, and reports its results to the Secretary, which will meet probably in June 1988, and by a process that it will go through, make recommendations, or findings, or deliver to the Secretary the results of their deliberations.

The Secretary is currently scheduled to make his decision on what is referred to as the preferred site in July 1988. Then there is a collection of environmental laws that have to be complied with. In order to fulfill that, a period of 6 months is planned to complete the final EIS and issue what is called a record of decision. Once the record of decision has been filed, then the site selection is final.

Between the time of the preferred site decision and the record of decision, we expect no new information to be introduced. It is a time for the people, if they wish, to submit comments on the environmental process.

Since the environmental expert is sitting next to me, I may be answering these things incorrectly, and in that case she can jab me in the ribs.

Senator McClure. Let the record show that she didn't wince while you were going through it.

Dr. Trivelpiece. I am relieved.

Senator Johnston. Well, Dr. Trivelpiece, I had a conversation with an eminent scientist the other night, and I said, "Do you think that we ought to build SSC?" He said, "Yes and no." He said, "Is it good to have? Is it good to do? Is it useful science? Definitely yes. Is it exciting? Yes. Will it train great minds and keep our best people? Definitely yes."

Should we cannibalize all the rest of science to build it? Definitely no. He said his fear was, which is my fear, that we cannot commit this much money on the SSC without not only cannibalizing other nuclear and high-energy physics research, but other scientific endeavors as well, unless we just pay for it out of the deficit, which I guess is large enough to encompass this.

Would you speak to that issue which is really the issue that will bedevil this committee?

PROJECT COST AND FINANCING

Dr. Trivelpiece. We were concerned about that for some time, almost a year ago, in discussions with the Secretary and other people throughout the administration, it should not go forward if it is going to come at the expense of the rest of science. We concluded it simply could not be done within the Department, and it should not be done at the expense of other science.

During the course of the Economic and Domestic Policy Council meetings that took place, one of the things that occurred was that the National Science Foundation's budget was going to be doubled in 5 years, and that is proposed in the administration's Quest for Excellence Supplement, which the President stated in the State of the Union Message.

If you calculate that out, doubling the National Science Foundation's budget over 5 years, in 10 years it turns out that it is approximately $10 billion of new money, which would be for small and university-type research that the Foundation is the principal supporter of.

In the same time, in the same system of units, the SSC would cost about $4.4 billion. You take those two together, and it kind of constitutes an unprecedented increase for basic research as proposed by the administration. We think that the NSF doubling, combined with the SSC, makes it very difficult to make a case that you are stealing from small science with the SSC.

Senator JOHNSTON. How much is it going to cost?

Dr. TRIVELPIECE. It is $4.4 billion, that is the current best estimate we have in 1988 dollars, in the same year dollars as the NSF doubling over 10 years, $10 billion. In escalated dollars, when construction, detectors, R&D, and preoperations costs are included, the estimate is $5.3 billion.

It is hard to see how, if the NSF budget increases along the lines proposed by the administration, that the SSC can really be crippling the rest of science. I hope that both of them go forward. It should not be an either/or proposition. We did support the NSF budget increase along with the request.

I can't forecast the future, and I understand people's concerns, but at least as we proposed it, we believe that if both of those are carried out, this is not going to occur in a way in which the sciences will be cannibalized.

NEED FOR HIGH ENERGY PHYSICS

Senator JOHNSTON. I read the materials about the fact that you need these energy levels in order to further dissect subatomic particles. I know you think you can prove your unified force theory, and some things of that sort.

Tell me, as you would tell the committee, were they here, why this is worth the kind of money that we would be spending on it?

Dr. TRIVELPIECE. Two ways, or two examples. One was Thompson, in 1897, discovered the electron, and he was using gas discharges and things like that. A distinguished group of British scientists, a group that was equivalent to the National Science Foundation now, wanted him to stop fooling around with these discharges and things and find something more important to work on, like steam.

Senator JOHNSTON. I thought that Ben Franklin invented electricity.

Dr. TRIVELPIECE. J.J. Thompson discovered the electron 90 years ago. Maybe somebody else would have discovered it, but when you think that one-third of our gross national product comes from our knowledge of the atom and atomic particles, that discovery was a very important one, plus the discovery of the neutron and the proton.

You take that 90 years ago, and then you go back to the mid-1930's, and positrons were discovered. In other words, the fact that not only are there electrons, but there is an antimatter version of an electron, which is a positron.

Imagine somebody in the 1930's trying to make a case for building an accelerator to go off and look at positrons. Here is something really ephemeral. Antimatter, it only exists for a short period of time, and when it fights with real matter, it anihilates and gives off gamma rays. What could be less practical?

Yet, today, positron emission transaxial tomography is the tool by which such things as Alzheimer's syndrome and brain disorders are being investigated, and capable of being treated or eliminated some day.

Now you look today, and you say, "Well, quarks are pretty abstract. If we want to learn the rest of the story about quarks, are we going to have any benefit from that?" I can't tell you that we are, but certainly looking back and trying to imagine a conversation we might have been having in 1933 or 1934, having watched the discovery——

Senator JOHNSTON. We know that quarks exist now.

Dr. TRIVELPIECE. You knew that positrons existed then, but why spend more money learning more about them? The people who pursued them at that time were doing so purely on a curiosity basis.

Senator JOHNSTON. I understand that, and I think that it is valid.

Why this sudden leap forward? We have Fermi Lab, and all of these other things, and they are operating at lower energy levels. All of a sudden we have to go all the way up to increased power, size, and cost.

Dr. TRIVELPIECE. I don't think that it is really all that sudden as your question might imply. The state of knowledge that we have today has grown as a result of accelerators in the past revealing that there was a large collection of subatomic particles.

The pattern begins to emerge, and the pattern is that you can build everything that you see in the universe out of six quarks and six leptons, and that makes up a model, and that model is called the standard model.

That model, together with some of the forces that influence these fundamental constituents, gives you a picture, a story of nature, but the story is incomplete if you don't know why electrons have the mass they do, or protons have the mass they do.

Why is it that if you cause two protons to collide together at an incredibly high speed, you produce a particle called a W-plus or a W-minus or Z, that these particles condense out at some mass which is 80 times heavier than a proton? That is a remarkable event.

What is the exchange between mass and energy? If you can condense energy to such a high degree, why does mass condense out? Why certain masses like protons, like electrons?

We don't know what the mass scale is. We don't know what the most fundamental element by which we go about measuring ourselves is; namely, what is the mass, the various objects that make up our universe. There is no guarantee that the next step will produce more understanding, but there is a strong belief that it will.

The next objects that are predicted, that understanding is required of, are things whose mass is a thousand times heavier than a proton. Mass converts into energy, and nuclear power and nuclear weapons are certainly good examples of mass going into energy.

It does work the other way. If you get energy to be focused in a small enough space and a short enough time, mass condenses out. The more the energy that you can condense, the greater the mass that you can condense out just from Einstein's formula $E=MC^2$. You normally think of mass converting to energy, but you can convert the energy to mass also.

Earlier accelerators gave the basis for the model. The six quarks and six leptons is the model. It gives rise to improved understanding, but it leads to uncertainty. The uncertainties require new experimental evidence. New experimental evidence requires being able to produce objects that are 1,000 times heavier than a proton. The SSC has been designed to put you high enough up on that threshold so that you are guaranteed that if there is something there, it will be capable of being discovered and understood.

Senator JOHNSTON. They used to talk about particles such as photons acting like particles. Then later they said that they act like waves or energy. That is a different kind of a phenomenon, and that phenomenon is well understood now.

Dr. TRIVELPIECE. Yes.

Senator JOHNSTON. We didn't need the accelerator to understand that, did we?

Dr. TRIVELPIECE. No; it was understood much earlier. Einstein received the Nobel Prize for a demonstration of photoelectric effects. The photons have a certain energy, and they behave like waves in certain cases, and in other cases they behave like particles. So you can demonstrate the wave particle by a number of experiments that are familiar to young physicists taking experimental courses in their freshman and sophomore years.

Senator JOHNSTON. Senator McClure.

BORON-NEUTRON CAPTURE THERAPY

Senator MCCLURE. Thank you very much, Mr. Chairman.

Let me turn for a moment to an area of medical opportunity. I know you are prepared to discuss with me, at least briefly, the Boron-Neutron Capture Therapy [BNCT] technology. There appears to be a growing international interest in that subject for the treatment of incurable cancers.

Countries, such as Japan, Germany, the United Kingdom, Sweden, and Australia are all conducting BNCT research. What is the United States, particularly the Department of Energy, doing in this area?

Dr. TRIVELPIECE. There is a small program, concentrated primarily at Brookhaven National Laboratory. But, as you indicate, there are certain tumors for which certain Boron compounds are taken up more rapidly than they are in normal tissue, and when irradiated in a broad flux of neutrons, these become radioactive and then will produce damage to the tumorous tissue, make it become necrotic and go away.

Senator McCLURE. That damage is confined to the cell in which it occurs.

Dr. TRIVELPIECE. It is confined locally to the region in which the boron is located, and the procedure is handled so that cancer takes up the boron more rapidly. That seems to work in certain circumstances. The Japanese do have some new data that indicate that this might be more efficacious than previously. I assume that that work is going on.

I understand there is some interest in using the facilities at Idaho in order to try to participate in this. I believe that is being given consideration. I have heard from people from Idaho about their interest in the possibility.

Senator McCLURE. What are your views on how closely the United States is to reinitiating human clinical studies utilizing BNCT technology?

Dr. TRIVELPIECE. I don't have the answer to that question, sir. I would like to do some research and give you that answer for the record. It would require some speculation on my part about the clinical readiness of something. I try not to practice medicine.

Senator McCLURE. I would appreciate it if you would supply a more comprehensive answer for the record.

Dr. TRIVELPIECE. Surely.

[The information follows:]

Boron Neutron Capture Theory

Since the clinical trials of Boron Neutron Capture (BNCT) that were terminated in the U.S. in 1961, definite improvements have been brought about in the delivery of both boron and neutrons to tumors. The only clinical trials subsequent to 1961 are those that have been conducted by Dr. Hatanaka in Japan. A number of groups in the U.S. are now devoting their efforts to exploring BNCT for clinical application.

In January 1986, a workshop on BNCT was held at the Brookhaven National Laboratory. Participants included representatives from the State University of New York at Stony Brook, the Idaho National Engineering Laboratory, Ohio State University, the Lewis Research Center (Cleveland, Ohio), the Massachusetts General Hospital, the University of Missouri, Harvard University, the University of California (San Francisco), the Callery Chemical Company (Callery, Pennsylvania), Nuclear Medicine, Inc. (Atlanta, Georgia), New York University Medical Center, Yale University, the Catholic University of Louvain (Brussels, Belgium), and Tufts New England Medical Center. The Department of Energy supports BNCT research at the Brookhaven National Laboratory, the State University of New York at Stony Brook, Ohio State University, and Tufts. The Brookhaven National Laboratory also has a cooperative program with the Idaho National Engineering Laboratory for the design of an improved filter for the neutron beam. The other principal areas of BNCT research involve efforts to develop better boron compounds for delivering the boron to the tumor, studies of the distribution and biological kinetics of boron compounds of potential utility, and studies of the efficacy and toxicity of boron compounds in animal models with spontaneous or implanted tumors.

Although some participants in the Boron Neutron Capture Therapy (BNCT) 1986 workshop thought that clinical trials could begin sooner, the consensus was that a great deal more basic work should be done in the areas of compound development and testing with animal models before clinical trials are resumed, and that this would involve a two to three year effort. We endorse the latter opinion.

The remaining problems involve neutron beam filter design and studies of the biodistribution and toxicity of proposed boron compounds. Regarding the filter, it is necessary for it to pass neutrons that are not so energetic as to be harmful, but which are of sufficient energy to penetrate to tumors at depth. Filter design studies, construction and testing are necessary. Among the remaining biological questions are, what is the optimum time interval between administration of the boron compound and neutron irradiation? What is the optimum mode and duration of administration of the boron compound to achieve maximum tumor to normal tissue ratio? Does sudden destruction of a large tumor mass in the brain create serious dangers such as hemorrhage? Is it better to complete the treatment in a single session or to distribute it over a period of days or weeks? Is the compound uniformly distributed with the tumor? If one tumor is treated, what is the probability that a similar tumor will soon appear in another region of the brain? How rapidly can regrowth occur in the irradiated tumor bed? And is the dose of the boron compound that is required for BNCT toxic?

Most of the work to date has concentrated on sulfhydryl boron hydrides, but other classes of boronated compounds such as porphyins and monoclonal antibodies should also be investigated. After selection of a compound through animal studies its distribution kinetics in human tumors should be investigated. These studies should include analyses of blood and tissue concentrations of boron, including tumor margins and normal brain adjacent to tumor.

Senator McCLURE. If you would include in that an evaluation from your standpoint of what obstacles still have to be overcome to begin treating humans that have that disease.

To what extent are the DOE and the National Cancer Institute [NCI] development programs interrelated?

Dr. TRIVELPIECE. There is discussion between NCI and DOE on programs. I think that your question probably implies a higher level of coordination than, in fact, is the reality.

The various programs, using the Los Alamos Meson facility, using the Berkeley accelerator, using the accelerator at Fermilab, and so on, those are sometimes funded and jointly managed with NCI support. On an individual investigator basis, there are a number of programs in which there is good correlation, but there is not sort of an interagency committee or working group that tries to do this correlation at a higher level, I believe.

Senator McCLURE. I am not even suggesting that it needs to be integrated, perhaps it doesn't.

Dr. TRIVELPIECE. I think that it works quite well right now.

Senator McCLURE. I am curious to know how well it is interrelated and whether or not there are advantages or disadvantages in the current relationship, or disadvantages, and a different kind of a relationship. If you could kind of give me some opinion of that, and supply that for the record.

Dr. TRIVELPIECE. It is a fair question.

[The information follows:]

BORON NEUTRON CAPTURE THEORY

The DOE programs are directed to developing methods, testing for feasibility and testing for toxicity. Preclinical studies for determining biodistribution and toxicity are conducted by DOE. It is expected that more extensive clinical trials to evaluate efficacy of the method in humans will be conducted under the auspices of the National Cancer Institute [NCI]. Also, the NCI currently supports a program in boron compound development that supplements the DOE effort in this area. Liaison with the NCI is maintained, in part, through attendance at meetings of the National Cancer Advisory Board.

Senator McCLURE. I don't know the answer to the question, and obviously I am seeking an answer.

I think, from the information that I have gotten, a Japanese doctor, Dr. Hanaka, has conducted some experiments in Japan where, after operating on this one kind of a tumor, he operates as you would in conventional brain surgery.

The tumor is one that is invasive in the adjoining tissues and, therefore, it is almost impossible to get all of the cancer cells, so some remain even after the operation. That is then the situs for the continuation of the disease, and it doesn't lend itself to surgical cure.

What he discovered was that the membrane permeability is buried in the cancer cell and, therefore, the boron passes into those cancer cells. In this particular instance, it is neutrons that react with the boron compounds and create the radioactivity. The energy level is very low so that the damage to the cell is confined to the cell in which the boron compound is located. Since the tumor takes up the boron and the radioactive result is confined to the cell where the boron is, and that is primarily the cancerous tumor cell.

In his experiment, they have a source of neutrons, but it is a very weak source of neutrons. They open the patient's skull, they operate, and they leave the patient exposed to the neutron radiation for 6 to 8 hours, while the skull is still open, and then they close the cell and hope that it has had an effect upon that tumor.

The theory is that a more intense beam of neutrons could do the same thing to a tumor without having ever opened the skull at all, or damaging the brain by the operation. With a large enough stream and intense enough beam of neutrons just on the general area of the tumor, a 10-minute treatment would do more good than the 6 or 8 hours of treatment that they are getting in Japan today.

The reason for the interest is that we have a facility that produces neutrons, and it is a facility that is mothballed right now because its experimental life was concluded. But it is still there and it could be rehabilitated. If we could develop a device which would focus this stream of neutrons sufficiently well, it might be able to be used at some point in the future to treat some 5,000 patients per year who die from that disease today.

I certainly am in no position to practice medicine either, and I am not attempting to do so, nor am I in a position to say that I know that what Dr. Hanaka has done really tells us that we can do it in a different way here, or that this facility will work. But we have a facility that is not being used now, and if it could be adapted, it seems to me that it is well worth the attempt to find out. I would invite your attention to that question, and look forward to your responses for the record.

Dr. TRIVELPIECE. I will provide it.

Senator MCCLURE. Thank you.

[The information follows:]

BORON NEUTRON CAPTURE THERAPY

Boron Neutron Capture Therapy [BNCT] has not yet been established as an accepted clinical procedure in this country. The Department of Energy has been engaged for the last 3 years in a national program of research aimed at establishing the safety and efficacy of BNCT. This program, centered at Brookhaven National Laboratory, but with important research activities taking place at Ohio State University, the State University of New York at Stony Brook, Massachusetts Institute of Technology, and New England Medical Center is expected to result in clinical testing of this therapeutic modality on patients with certain brain tumors in another 2 or 3 years. Prior to the clinical studies, it is necessary to establish the safety and efficacy of BNCT through animal studies and pilot clinical studies. When this has been achieved, it is expected that funding for more extensive clinical studies would be requested by the National Cancer Institute.

The INEL Power Burst Facility is one of the few reactors in the United States with an adequately high flux of neutrons to be used for this kind of radiation therapy. It may play an important role in the implementation and, possibly, in the National Cancer Institute clinical testing of BNCT.

ALCOHOL FUELS RESEARCH

Mr. Chairman, if I might return for a moment to Miss Fitzpatrick's testimony. There is very little in that testimony with respect to alcohol fuels.

I want to carefully phrase the question because I don't want to prejudice the answer. I want to really find out what your thinking is with respect to the maturity of the technology for production of alcohol, ethanols, primarily.

If I read your testimony correctly, you are really looking at two or three very narrow, specialized production technologies. Is that correct?

Miss FITZPATRICK. Yes.

Senator McCLURE. The balance of the technologies used in ethanol are familiar, they are well understood, and you don't know of anything that is really going to change or improve those processes.

Miss FITZPATRICK. That is true.

Senator McCLURE. The focused efforts you have do have promise.

Miss FITZPATRICK. Yes; I think so.

Senator McCLURE. Do you have any idea of when or what your timetable may be with respect to the progress to be made on those areas where you are focusing attention?

Miss FITZPATRICK. We are focusing attention, as you point out, on a couple of production possibilities, first trying to understand what goes on in the production of ethanol, which is a biological process that has not been completely understood. We know how to do it, and knowing on a molecular scale what is actually going on is a little bit more difficult.

We are addressing several issues. First, how can we speed up the production rate, whichever mechanism is being used, and we have had considerable success in doing that. Getting the yeast to ferment at higher temperatures. Usually, a high temperature will kill the yeast, but if you can get it to work at a higher temperature, you can speed up the production rate by a factor of several times. We have been successful in doing that and hope for further success.

Also, if we can use feedstocks that are now not available for fermentation, because we don't have enzymes that will allow the fermentation, then we could greatly reduce the cost of ethanol and make it more attractive, therefore, a more viable industry. We are also having success in converting cellulosic and lignolosic feedstocks, woody and grassy types of feedstocks, to fermentable starches and sugars.

ENZYMES RESEARCH

Senator McClure. You mentioned enzymes. If I understood your statement with regard to enzymes, what you are focusing on is enzymes that might be useful in different kinds of feedstocks.

Miss Fitzpatrick. That is right.

Senator McClure. You are not really looking at enzymes that will do more for the feedstocks of the type that you are using now?

Miss Fitzpatrick. We are looking at those also, especially to increase the temperatures at which the fermentation processes can take place and, therefore, increase the rate at which they take place.

Senator McClure. The enzymes greatly shorten fermentation time.

Miss Fitzpatrick. That is right. Fermentation would not occur without them.

Senator McClure. One of the reasons I asked that question is that there is a great deal of interest right now in the farm problem. We spent $26 billion this last year on farm economic support programs. This $26 billion expenditure only kept them alive for 1 more year, but didn't provide any answers.

Miss Fitzpatrick. That is right.

Senator McClure. Keeping people alive for 1 more year is worth doing, but it is not a permanent solution. If we can find a way in which we can develop a viable ethanol program that consumes produce from the farm, we might begin to solve a very basic problem with respect to agriculture today, and take some part of that $26 billion and apply it to an answer, not just to a palliative.

Miss Fitzpatrick. It is certainly a major goal of our program, Senator, to develop crops, and the thermal and chemical and biological conversion processes to convert those crops into fuels. We are working on all aspects of that cycle.

Senator McClure. I am not going to ask you to change the focus of your program, but I can't help but make the statement right now that if $8 or $10 billion out of the $26 billion would support an ethanol program, as I believe it would, that $10 billion ethanol program would take 30 million acres of production, we would have done a great deal to alleviate the economic crisis on the farms and in rural America.

We would do it not just in the name of an agricultural program, but it would also be an energy program, and a part of our independence. It would do something with respect to the other side of the equation, and that is the efficiency of combustion, in environmental terms, and the efficiency of combustion of the engine, all of which it enhances; is that correct?

Miss Fitzpatrick. Yes; it is true, your point is exactly correct. We have a great many interrelated things going on, and we need to solve all of them together.

Senator McClure. It seems to me that we segment this problem. We look at ethanol as a process. We look at it as an economic product. We look at a farm program as a separate program or problem. We look at energy as a separate problem or program. We look at internal combustion engine efficiency another way. We look at the environmental performance of internal combustion of an engine in a different way. We have never related them.

Miss FITZPATRICK. Maybe I am the only one in the world that does it, but I have all of those offices from an energy perspective under me. I certainly think in those terms, Senator. We need to have engines that are both more efficient and fuel flexible, that can burn alcohol.

We need to have the ability to grow crops, and I use the word "crop" precisely, crops that are convertible to useful fuels, whether they are liquid or gaseous. We need to understand the biological and chemical processes through which the conversion occurs. We need to do this in a way that is economically competitive so that it eventually will not require any government subsidy.

Senator McCLURE. Just as an example, I think you would agree that when we went into the environmental controls that we found necessary to protect human health, one of the decisions that was made by our country was to get lead additives out of gasoline, and that was done because General Motors decided that it was easier to clean up the exhaust stream than to clean up the combustion process.

In order to clean up the exhaust stream, they wanted to put a catalytic converter on to take care of the unburned hydrocarbons, but to make that function well, they needed to get rid of the lead that might otherwise fail the catalyst. In order to do that, they had to also lower the compression ratios of the internal combustion engine by lowering its fuel efficiency.

Is that right so far?

Miss FITZPATRICK. Yes, sir.

Senator McCLURE. Taking away its power.

Miss FITZPATRICK. That is right.

Senator McCLURE. In order to compensate the no-lead order, which is now being entered by EPA, the refiners are trying to maintain or increase the octane ratings that allow the compression ratios that are a part of the efficiency question. They refine to get some high aromatics into that gallon of gasoline.

I think that there is about a 7 or 8 percent volumetric penalty in terms of the efficiency of the refining process in order to get those aromatics in. Those aromatics are also, upon combustion, the basis of the photosynthesis that is the basis of the killer fogs. So, we really do have an environmental problem on the one end, and we have an economic and energy problem on the other end, as we try to solve this problem of maintaining octane ratings as we take lead additives out.

ETHANOL RESEARCH

Ethanol supplies an answer to much of that, and yet we don't seem to have related in cost to the question of ethanol additives as a substitute for lead additives. We say that ethanol doesn't compete with gasoline, but that is the wrong question. Does ethanol compete economically with the high end aromatics?

Miss FITZPATRICK. Right now, at the current prices of oil, Senator, it is very tight, and it is tending to lose the battle.

Senator MCCLURE. Certainly you lose the battle if you look at gasoline as the total gallon.

Miss FITZPATRICK. That is right.

Senator MCCLURE. I don't think that you lose the battle if you look at the high-end aromatics themselves.

Miss FITZPATRICK. I have asked that question, Why wasn't there, since many people said it would happen. When the EPA ordered the backing out of lead, many people said, now we are going to have a new market for ethanol. As you know, the Department is heavily involved in ethanol in various ways.

That market has not materialized to a large extent, in part because, at the same time that lead was being phased out and the companies were using up their lead credits, which took about a year, we had the precipitous fall in the price of oil and, therefore, in the cost of those high-end hydrocarbons that you refer to as being octane enhancers, and they are. Therefore, ethanol was caught again.

It still costs about $1.40 a gallon or more to produce ethanol.

Senator MCCLURE. What does it cost to produce the high-end aromatics?

Miss FITZPATRICK. I understand that it is about $1.15 a gallon.

Senator MCCLURE. So there is a 30-cent spread.

Miss FITZPATRICK. Right; so ethanol is still losing.

Senator MCCLURE. Is that your own analysis of the cost, or is that something handed to you by the oil companies?

Miss FITZPATRICK. No; that is what we observed in the market, and that is what the DOE figures that I have been given show.

Senator MCCLURE. I don't think that anybody expects me to be an oil company basher. I am not doing that in this instance. But doesn't it make sense, if you own a refinery, and you own the feedstocks, that you are going to run your own refinery with your own feedstock before you will take an alternative?

Miss FITZPATRICK. That is probably true; yes. After all, if you are refining a barrel of crude, you are going to look for some way to use everything that comes out of that barrel. You will probably take kind of a cost premium before you will go to an outside source.

Senator MCCLURE. It seems to me that this is predictable.

Miss FITZPATRICK. That is right.

Senator MCCLURE. I don't even blame them for doing that, but maybe we ought to be blamed if we don't question that a little bit more closely.

Miss FITZPATRICK. I appreciate your concern for increasing the use of ethanol, and methanol also. I think that those are certainly the direction we ought to be headed in. But the key to it is evidently that we are going to have to get a substantial reduction in the cost of producing those fuels, and that is what we are working on.

Senator McClure. Perhaps, and this is out of your bailiwick, paying them 30 cents a gallon to put it in.

Miss Fitzpatrick. We wouldn't like to do that on a long-term basis. The answer in the long term, I would hope, is that we would have the technology available to produce those in an effectively competitive fashion.

Senator McClure. If you spend a few hundred million dollars paying that, and save a few billion dollars on farm support program, wouldn't that be a good overall trade?

Miss Fitzpatrick. It might be, Senator, except that it tends to have a perverse effect on the market. If you remove the incentive to get the cost down by cushioning the difference through a subsidy, then the market tends to live very happily with that subsidy, and it doesn't make the investment that it should in improving the ethanol technology. So it could be counterproductive.

Senator McClure. I understand that argument, but I assume that if they could get the subsidy and still do it cheaper, they could make more money.

Miss Fitzpatrick. But they would not have the incentive to get it cheaper. We are not there now, and you would tend to remove the incentive to get there more cheaply if you subsidize the difference that now exists.

Senator McClure. Unless doing it more cheaply made their bottom line better?

Miss Fitzpatrick. Yes; even beyond the subsidy.

Senator McClure. Even oil companies are concerned about the bottom line.

Miss Fitzpatrick. Yes, sir.

Senator McClure. Even Senator Jackson agreed with that.

Miss Fitzpatrick. And even the Department of Energy.

Senator McClure. Thank you very much, Mr. Chairman.

CUSTOMER RESISTANCE TO ETHANOL

Senator Johnston. Thank you. Ms. Fitzpatrick, what is the basis for the huge customer resistance to ethanol?

Miss Fitzpatrick. The resistance so far has been to methanol that we have seen explicitly. There is some resistance also to ethanol. I understand that there are advertising campaigns by companies who are not using it, claiming that there can be damage to engines.

We know that too rich a mix of methanol can damage certain engine components and the fuel line, especially certain polymers. It can interfer with the lubrication in an engine.

Senator Johnston. What about the ethanol?

Miss Fitzpatrick. Ethanol doesn't seem to have that effect. Ethanol seems to be OK, but that can be a fine point in the public mind when you are working on an advertising campaign. I noticed that one company is advertising pure gasoline. Gasoline has never been pure, but the implication is that it doesn't have any alcohol in it. A few years ago, they were advertising detergent in the gasoline.

Senator JOHNSTON. We have a big program for ethanol in my state, and there is $1.40 subsidy for it, but it is not selling. Indeed, the gas stations there are saying, "No Ethanol" or "No Gasohol" in this gasoline. There is some basis, and I haven't checked with people as to why they feel that way.

ETHANOL REFINING

Miss FITZPATRICK. I think that probably Senator McClure touched on it. If you are refining, and you have certain things coming out of the refinery, you want to use as much of it as you can. So you take some of those higher fraction hydrocarbons, and use them as an octane enhancer, then you proceed to bash all of your competition who made another choice. It is simply a dog eat dog market.

It is not necessarily based on fact. It is not necessarily based on truth, justice, and the American way, as Dr. Trivelpiece says. I think that it is regrettable because I think that possibly some of the fear that has been instilled in the public mind is not justified.

Senator JOHNSTON. I think that it would be very useful if you all did some kind of market survey, particularly in my state where they use so much of it. It would be very easy to talk to a lot of people who use gasohol and find out what their experience was.

Miss FITZPATRICK. Yes.

Senator MCCLURE. Would the Senator yield?

I think that there has been a little bit of concern on the basis of the release of corrosion in tanks and pipelines. This is particularly true in shipping alcohol through a pipeline; you clean the pipeline, and that means that you get a lot of dirt along with it.

The same thing is true to a smaller degree in a lot of old service station gas tanks. You get all of that corrosion out of them, and they start leaking. I think there has been a little bit of problem in perception, at least, to the degree of that problem.

I don't think that it is that serious of a problem, but if it is in perception a serious problem, they are going to avoid it.

Miss FITZPATRICK. I think that that is correct. It is not completely without basis. If somebody can use it as an excuse to blow it up a little bit, if he thinks that he can get a competitive advantage out of it, it is a natural reaction.

Senator JOHNSTON. I would certainly recommend that you do that market survey, if no other reason, you have a big loan guarantee down there, on the plant in Louisiana.

Miss FITZPATRICK. We have several big loan guarantees.

Senator JOHNSTON. If ethanol gets a blackeye improperly, you might get a big blackeye with it.

Miss FITZPATRICK. Yes.

SUPERCONDUCTING SUPER COLLIDER

Senator JOHNSTON. Dr. Trivelpiece, just one more question here.

You have indicated that $10 of your $35 million request is for construction. Why do you need the $10 million for construction when we won't have a site until 1989, and does that $10 million commit us to anything if we appropriate it?

COMMITMENT TO PROJECT CONSTRUCTION

Dr. TRIVELPIECE. Yes; it is for certain long leadtime items. In order for a construction project to be considered, there needs to be a construction data sheet. The construction data sheet needs to have some funds identified with it. We had the difficulty of the fact that the SSC decision was made subsequent to the time the State of the Union Message was delivered, and the budget was already submitted here.

We reallocated funds within the High Energy Physics Program into two groups. One group was to continue the R&D necessary to do the magnet work, and so on, that anticipates the project. The other was to identify some level of funds to initiate construction activities. These are long leadtime items that would be used should it be approved.

There is nothing magic about the $10 million, only that it was a compromise between not trying to reduce the ongoing program at Fermilab and Stanford and, at the same time, identifying sufficient funds that would be appropriate for initiating the construction, since we need it.

Senator JOHNSTON. It doesn't commit us to anything? It does not commit us to construction?

Dr. TRIVELPIECE. If funds for the project are appropriated, I would hope that that would be some level of commitment from Congress. My understanding is that the administration, in order to have a project considered for appropriation, needs to request some funds through a construction data sheet and this is the amount that was put in there. Then there is the outyear funding that is requested for the total project.

Senator JOHNSTON. Through the appropriation process, though, as you know, many projects are authorized. What would be the meaning, aside from the fact that you get some long leadtime items, of this $10 million? What is the significance of that in the appropriations process?

Dr. TRIVELPIECE. It would be my understanding that if the funds are appropriated, then the Department of Energy would proceed with the site selection process and try to ask for the funds next year for the beginning of the formal construction. In the 1989 budget, we would be asking for something in excess of $300 million.

Senator JOHNSTON. Would you enter into any long leadtime contracts which would bind us beyond the $10 million?

Dr. TRIVELPIECE. No; I see the nature of your question. There would be a collection of things that a commitment to purchase them could be made, and they would be purchased, presumably, if a contract had been let and funds are appropriated. There would be no commitment beyond that of the subsequent appropriation.

Senator MCCLURE. If the chairman would yield.

Senator JOHNSTON. Yes.

Senator MCCLURE. I want to say, the way I understand it, to make sure that I understand both the question and the answer, before the administration would feel free to include in the next budget submission the money necessary for the construction of the SSC, you feel you have to have congressional authorization for that process?

Dr. TRIVELPIECE. Yes; congressional approval in the form of an authorization or appropriation, and that is why we did it this way.

Senator McCLURE. You need either a direct authorization of the project, or an appropriation which would be treated as an authorization for the project as the basis for your budget request for the fiscal year.

Dr. TRIVELPIECE. That is my understanding. We could not proceed to the site selection without congressional approval.

Senator McCLURE. If we put the $10 million in, that is the "go" signal for you, still subject to the control of the Congress, but nevertheless gives you the authority you need in order to include that in next year's budget submission?

Dr. TRIVELPIECE. Yes, sir.

Senator JOHNSTON. We will undoubtedly get this appropriation bill out in June or July, before the August recess. My guess is that the authorization bill would not be passed by that time.

My strong feeling is that we will not be ready to make an irrevocable commitment to construction of this project by June or July. So it is vital, if we are going to give you that extra $10 million, that we do so under the rubric of no final commitment to the SSC.

Perhaps we need to refine our language here a little bit, if we give you that $10 million, maybe put long leadtime items.

Dr. TRIVELPIECE. They are identified as such in the construction data sheet request.

Senator JOHNSTON. You might give us a letter to give us some new language for that because we don't want to run Senators off from what they would otherwise appropriate, because of fear of not wanting to buy a $4 billion machine prematurely.

Dr. TRIVELPIECE. I understand that we work on a year-by-year appropriation here, and that this does not commit beyond the $10 million that would be appropriated, if you decide to do so, but we are also including in the invitation for site proposal, and I have letters that have gone to Governors previously, a clear indication that this is still being done subject to the approval of Congress of the funds for this activity. The proposers are preparing their proposals at their own risk, and we have that carefully worded so that there is no misunderstanding.

PREPARED STATEMENT

Senator JOHNSTON. Very good.

Have you finished your presentation, Dr.Trivelpiece?

Dr. TRIVELPIECE. I could go on for some time. I think that you have asked enough questions to cover the whole statement.

Senator JOHNSTON. We have a whole series of written questions which I will incorporate in the record for your response.

Dr. TRIVELPIECE. I will be delighted to respond to those.

[The statement follows:]

STATEMENT OF ALVIN W. TRIVELPIECE

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear here today to present the FY 1988 budget request for the programs supported by the Office of Energy Research (ER). These programs are: High Energy and Nuclear Physics, Basic Energy Sciences, Magnetic Fusion Energy, Biological and Environmental Research, Energy Research Analysis, University Research Support, University Research Instrumentation, and Multiprogram Energy Laboratories-Facilities Support. The High Energy and Nuclear Physics programs are under the General Science and Research appropriation. All of the other programs are under the Energy Supply R&D appropriation. The FY 1988 budget request for the programs that I will discuss today is shown in Table 1. This budget request reflects the goal and strategies set out in the Fifth National Energy Policy Plan (NEPP-V). At this time I would like to discuss each of the programs mentioned above in some detail.

HIGH ENERGY AND NUCLEAR PHYSICS

The High Energy and Nuclear Physics (HENP) programs address questions at the frontier of science. The fields of high energy physics and nuclear physics evolved from investigations of the atomic nucleus during the first half of the twentieth Century. Today, researchers in these fields continue to seek a better understanding of the fundamental constituents of matter and the basic forces that govern them. These constituents, the forces that act on them and the physical laws governing their interactions form the basis for all the physical sciences.

In the last 25 years, remarkable progress has been made in discovering and understanding the fundamental constituent particles of matter and the forces of nature that govern them.

Table 1
Office of Energy Research
Summary by Program
($ in millions)
Budget Authority

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
General Science & Research			
High Energy Physics	$490.4	$499.7	$566.6
Nuclear Physics	172.5	217.0	245.1
General Science Program Direction	2.1	2.5	2.8
Transfer of Appropriation	-6.0	0	0
Subtotal	$659.0	$719.2	$814.5
Energy Supply - R&D			
Basic Energy Sciences	$419.8	$525.5	$479.1
Magnetic Fusion Energy	361.5	345.3	345.6
Biological & Environmental Research	178.0	194.0	217.5
Energy Research Analysis	2.6	2.0	3.7
University Research Support	10.2	15.8	13.4
University Research Instrumentation	6.2	5.0	5.0
Multiprogram Energy Laboratories- Facilities Support	39.9	56.7	56.6
Advisory & Oversight Program Direction	2.7	2.5	3.2
Policy and Management	0.1	0.5	0.6
Subtotal	$1,021.0	$1,147.3	$1,124.7
Total ER	$1,680.0	$1,866.5	$1,939.2

Scientists have learned that all macroscopic matter is made up of chemical elements--of which the smallest distinguishable unit is the atom. Each atom has a central core, the nucleus, containing most of the atom's mass, and electrons, which move around the nucleus and are members of a family of particles called leptons. The nucleus is composed of protons and neutrons, which, in turn, are now known to be made up of fundamental particles called quarks.

Experiments in the High Energy and Nuclear Physics programs depend primarily on large experimental facilities that accelerate beams of particles to collide with stationary, or fixed, targets or head-on with other moving particle beams. By using large detector systems to study the results of these collisions, scientists can learn about the properties of the underlying building blocks and basic forces involved. Progress depends on a continuing interplay of advancements in experiment, theory and technology.

Often, the range of experiments possible is limited by available technology and physicists frequently have to develop new equipment and technology to carry out the most important experiments.

Over the years, DOE-supported research in High Energy and Nuclear Physics has made contributions in many areas, including energy, education, health, industrial development and national defense. Contributions from the HENP programs come not only from the direct results of the research, but also from technological spinoffs and from the training of tomorrow's scientists through participation of university graduate students in carrying out the research. Although specific contributions cannot be predicted, they occur frequently. For example, scientists at Brookhaven National Laboratory (BNL) recently developed a device called a triple preamplifier. This device amplifies small electrical charge impulses from various types of nuclear radiation detectors. Although it was developed for physics experiments, it can be used in medical and nuclear electronics and in nuclear instrumentation for oil and gas exploration. In October 1986, BNL received a prestigious IR-100 award from Research and Development magazine designating this device as one of the 100 most significant new technical products of the previous year.

HIGH ENERGY PHYSICS

The major current objectives of high energy physics research are to develop a unified description and understanding of the basic forces of nature--that is, a single theory that would describe all the interactions of matter and energy existing in the universe--and to search for the most fundamental constituents and phenomena which will extend understanding of the basic nature of matter and energy.

High energy physicists are developing an increasingly better understanding of the forces of nature and the unifying connections among them. The four fundamental forces are the electromagnetic force, the weak force, the strong force and the gravitational force. Unification has been a reliable guide to physics research. It is a search for linkages between apparently diverse phenomena in an effort to discover underlying simplicity. A part of the recent progress in high energy physics has been the conceptual unification of the weak nuclear and electromagnetic forces into a single "electroweak" framework. In addition, a theory of the strong force has emerged which is consistent with observation. There is increasing anticipation that the unification of the strong nuclear and the electroweak forces into one "grand unified" framework may be possible, thus reducing the apparent number of forces in nature to two. The ultimate goal is a "super-grand" unification that would bring all of the forces in nature into a single unified framework.

The picture of nature composed of the electroweak and strong forces and a small set of fundamental constituents is known as the Standard Model. The most significant recent experimental results all reinforce the predictions of the Standard Model. Although no deviations from the Standard Model have been found, scientists believe that it cannot be the final answer because, for example, it does not explain the origin of mass and it does not include gravity (one of the four forces of nature). Experiments using newly available research capabilities will test the Standard Model, and will search for phenomena that do not conform to the Standard Model as well as for phenomena predicted by newer theories.

Before I turn to the budget request, I would like to discuss some of the recent and ongoing accomplishments in the High Energy Physics program. At Fermi National Accelerator Laboratory (Fermilab), the Tevatron, the world's first high energy accelerator using superconducting magnets, is now operating at 900 billion electron volts (GeV) for physics experiments. Scientists can now carry out fixed-target experiments at higher energies and with new beams not previously available. They also can conduct colliding beam experiments with antiprotons and protons at higher energies than available anywhere in the world. An antiparticle, in this case an antiproton, is an elementary particle identical to another elementary particle in mass but opposite to it in electric and magnetic properties. Colliding beam experiments with 900 GeV protons on 900 GeV antiprotons began in mid-January with events being recorded in the Collider Detector at Fermilab (CDF). Successful completion and operation of this antiproton source is a major technological achievement. The Tevatron is now the world's highest energy accelerator and collider, with an energy three times greater than the normal operating energy of the CERN collider in Europe. The CDF is also a major technological achievement. The detector was fabricated by a group of scientists with participants from 3 U.S. laboratories, 10 U.S. universities and major contributions by the Japanese and Italians. The detector consists of a 2500 ton movable central detector and two 1000 ton detectors capable of detecting particles called muons. In addition, the final elements of the upgraded fixed-target experiment capability of the Tevatron are now completed. Operation for experiments is expected to begin in the spring. Results of the analysis of the 1985 Tevatron fixed-target run include a new, substantially more precise measurement of the lifetime of particles containing a type of quark called a charmed quark.

At the Alternating Gradient Synchrotron (AGS) at BNL, scientists are doing experiments with beams of particles called neutrinos for studies of rare processes that imply that neutrinos, which were previously thought to be massless, might in fact have a tiny mass. The existence of such an effect, if found, would be the first evidence that the Standard Model is incomplete. Later in this statement, I will discuss research with similar implications that is being sponsored by the Nuclear Physics program. Researchers at AGS also are using high intensity beams of particles referred to as kaons for precision studies of their decay into rare modes.

At the Stanford Linear Accelerator Center (SLAC), substantial progress is being made on the installation and testing of the Stanford Linear Collider (SLC). First physics operation is expected in the spring of 1987. Successful operation of the SLC will provide an essential demonstration of the technical feasibility of using linear accelerators with precisely controlled, high intensity and highly focused beam pulses to provide high rates of electron-positron collisions at energies far beyond those that will be affordable for circular colliders. (The positron is the antiparticle of the electron.) The SLC will also permit significant new physics experiments with 50 GeV on 50 GeV electron-positron colliding beams, a well as the copious production of Z zero particles. The Z zero particle is one of a family of particles that carry the electroweak force. The upgraded Mark II detector is in final stages of preparation and will be ready to take data this spring with emphasis on studying the Z zero particle. All of these accomplishments are adding to our steadily growing understanding of the fundamental constituents of matter and the forces that govern them.

FY 1988 HIGH ENERGY PHYSICS BUDGET REQUEST

The FY 1988 request for the High Energy Physics program is $566.6 million. Of the total amount, $438.7 million is for Operating expenses; $76.7 million is for Capital Equipment; and $51.2 million is for Construction (Table 2).

As the Subcommittee is aware, President Reagan has approved construction of the world's largest and most advanced particle accelerator, the Superconducting Super Collider (SSC). The SSC is a major science initiative which demonstrates the commitment of this Administration to enhance the economic and technological competitiveness of the United States. The SSC will be the world's most advanced particle accelerator facility; its energy level of 20 trillion electron volts per beam will be 20 times the present highest energy available in the world at the Tevatron near Chicago, Illinois.

The SSC is on the cutting edge of man's quest to understand the nature of the world in which he lives. Profound achievements along this path of research have included new insights and understanding related to gravity by Newton and Gallileo, electricity and magnetism by Maxwell and Hertz, the atom and

Table 2
High Energy Physics
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses			
Physics Research	$105.8	$109.4	$116.7
Facility Operations	173.0	208.4	233.3
High Energy Technology	86.6	80.5	88.7
Subtotal	$365.4	$398.3	$438.7
Capital Equipment	70.0	70.1	76.7
Construction	55.0	31.3	51.2
Total High Energy Physics	$490.4	$499.7	$566.6

nucleus by Rutherford and Fermi, and relativity by Einstein. Scientists exploring the subparticle structure of matter and unification of the basic forces today are at the forefront of this quest. This type of research has resulted in many U.S. scientists being recognized by Nobel prize awards in recent years.

R&D studies for the SSC were formally initiated late in 1983 in conjunction with special Congressional hearings. The R&D was conducted at leading high energy physics laboratories and other institutions as a coordinated national effort under the guidance of the SSC Central Design Group (CDG) formed by the Universities Research Associates, Inc. A detailed Reference Designs Study, completed in March 1984, established the basic feasibility of the SSC, provided a preliminary cost estimate, and identified R&D needs. Following this, much R&D was done to verify the assumptions of the Reference Designs Study. In 1986 the CDG completed the SSC Conceptual Design Report which was thoroughly reviewed by the Department of Energy with the aid of many independent experts. This process led to the conclusion that the project was technically feasible and that the cost and schedule estimates were sound. The project has also been reviewed by the High Energy Physics Advisory Panel; and the SSC project earned the strong support of the high energy physics community. As the FY 1988 budget process evolved, the Department of Energy also thoroughly reviewed all aspects of the project via its established major systems acquisition review system. The Secretary publicly announced his support of the project in December 1986 and indicated his intention to seek Administration approval for the SSC. The Administration's deliberations concluded with a presentation before the President and the Domestic Policy Council on January 29, 1987. The following morning President Reagan gave his approval to proceed with the

Supercollider and Secretary Herrington announced the decision that afternoon.

As currently envisioned, the SSC will be a 20 TeV on 20 TeV proton-proton collider, the heart of which is two rings containing about 10,000 superconducting magnets located in a racetrack-shaped tunnel about 52 miles in circumference and 10 feet in diameter. There are four interaction regions at which experiments will be carried out with detectors that record the results of the collisions between protons. The SSC will be a powerful basic research tool that significantly extends the frontiers of understanding of the basic nature of matter and energy. Research at the SSC is designed to answer many unanswered questions that cannot be addressed by any facility in the world either in operation or under construction. We expect that the SSC will have significant research results and technological spinoffs and innovations that should profoundly touch every human being.

The total project cost of the SSC is estimated to be $4.4 billion in FY 1988 dollars, including the costs of R&D, detectors, computers and pre-operations. In escalated dollars, this becomes $5.3 billion. We estimate that with an FY 1988 project start the target completion date of SSC is 1996. In FY 1988 we are requesting $10 million for construction and $25 million for R&D related to SSC. No determination has been made as to where the SSC will be sited. The Department has announced its plans for an open, competitive and equitable site selection process. We anticipate that the site will be provided at no cost to the government. We are actively seeking cost-sharing from foreign countries, industry, and state and local governments. The Department is proud to present this request to the Congress, and we look forward with great anticipation to this historic undertaking.

As noted earlier, experimental research in high energy physics requires the use of large particle accelerators, colliding beam devices and large particle detectors. A major part of the funding for the program is required to meet the direct needs of the accelerator laboratories to develop, maintain and operate these research facilities.

Within the FY 1988 request for Operating Expenses of $438.7 million, high priority will be given to Facility Operations for the new world-class collider facilities at Fermilab and SLAC, the Tevatron 900 GeV on 900 GeV proton-antiproton collider and the Stanford Linear Collider 50 GeV on 50 GeV electron positron collider, as well as the new Tevatron fixed-target facilities. These facilities first came into operation during FY 1987 and will be available full-time for research in FY 1988. The increase in operating funds requested for FY 1988 is for enhanced operation of these new facilities. Operation of the upgraded Positron Electron Project (PEP) collider and the SPEAR collider at SLAC will be resumed and operation of the Alternating Gradient Synchrotron research program at BNL will be supported at a constant level.

The Operating Expenses request for the Physics Research activity provides a somewhat enhanced level of effort consistent with the operating level of the facilities. This activity supports university and laboratory research groups who carry out experimental and theoretical research in high energy physics.

The FY 1988 Operating Expenses request also provides for continuation of the current level of effort in the High Energy Technology activity. Continued pursuit of long-range accelerator and detector R&D studies to develop new and advanced concepts and technologies will receive priority. R&D on the SSC will be continued with emphasis on fabricating and testing full-size magnets to further refine the magnet design.

The FY 1988 Capital Equipment request of $76.7 million gives priority to continued progress on the large collider detectors at Fermilab and SLAC. Capital Equipment funding is required to provide the secondary beam line components, particle detection apparatus, portable shielding and data analysis systems essential to do high quality, forefront high energy physics experiments, This funding is also required to replace accelerator and detector facility components that are worn out or obsolete. In FY 1988, priority will be given to continued progress on the fabrication of the D-zero detector for the Tevatron collider and the Stanford Linear Detector for the Stanford Linear collider so that first physics experiments for these detectors can begin in late FY 1989.

The FY 1988 request for Construction funds is $51.2 million. The projects are listed in Table 3. The request includes continued work on upgrading the central computing capability at Fermilab ($11.0 million), which is required to analyze the large volume of new physics data coming from the Tevatron program, and continued construction of the AGS Accumulator/Booster at BNL ($8.3 million). The Accumulator/Booster will improve the performance and capabilities of the AGS, will make previously inaccessible areas of science available to researchers and will significantly increase the data collection rate for the experimental program already planned and underway at the AGS. The Construction request also includes funds for Accelerator Improvement and Modifications Projects ($11.2 million) that are required to maintain the scientific effectiveness and the operating reliability and efficiency of the accelerator and colliding beam facilities. The request also provides $10.7 million for General Plant Projects which are required to keep the general plant of the laboratories (e.g., buildings, roads and utilities) in good operating condition.

Table 3
High Energy Physics
Budget Authority
($ in millions)

Construction	FY 1988 Request	TEC	Completion Date
Superconducting Super Collider (88-R-103)	$10.0	4010.0	FY 1996
Central Computing Upgrade, Fermilab (86-R-104)	11.0	24.6	FY 1989
AGS Accumulator/Booster, BNL (86-R-105)	8.3	30.6	FY 1991
Accelerator Improvements and Modifications Projects (88-R-101)	11.2	11.2	FY 1990
General Plant Projects (GP-E-103)	10.7	10.7	FY 1990
Total Construction	$51.2		

NUCLEAR PHYSICS

The primary goal of the Nuclear Physics program is to understand the structure and interactions of atomic nuclei. Although nuclear processes, and the many particles used in nuclear physics research, are complex and require much hard work and innovative experimentation to understand, the underlying concepts are rather simple. Nuclear processes determine the physical characteristics of our universe--from its creation as a primordial mix of energy and elementary particles, to the reactions that power our sun and the composition of the elements that make up our planet. An understanding of nuclei and nuclear phenomena is essential to any basic understanding of the world around us.

The body of knowledge resulting from basic nuclear research has grown systematically over the years and has had enormous influence over other branches of science and technology, such as nuclear power, nuclear weapons and nuclear medicine. Only slightly less well known are nuclear techniques for geophysical exploration, testing of materials and archeological dating and siting. The inclusion of the nuclear data program within Nuclear Physics tacitly recognizes the inseparable aspects of the basic and applied nature of nuclear research.

Over the years, many theoretical models have been developed to approximate the structure of the nucleus and its behavior. Although initially very promising, the descriptions of nuclear phenomena provided by these models have ultimately proven to be somewhat disappointing, leading to the recognition that something basic has been lacking in the models. Scientists now know that neutrons and protons, the constituents of the nucleus, are composed of smaller constituents called quarks. Nuclear theorists, along with high energy theorists, are investigating the ways quarks are confined together in groups of three to make protons and neutrons. Based on these concepts, a more fundamental theory of the strong force, which holds the nucleus together, is emerging. This new theory, called quantum chromodynamics, is altering our understanding of nuclear matter in major ways.

The Nuclear Physics program continues to increase our knowledge about atomic nuclei as well as our capability to expand that knowledge base. Let me describe some of our recent accomplishments before turning to the FY 1988 budget request.

The AGS at Brookhaven National Laboratory is now able to accelerate heavy ion beams. On October 24, 1986, oxygen ions generated in the Brookhaven Tandem Van de Graaff accelerator were sent via the new heavy ion transfer line to the AGS where they were accelerated to the full design energy of 14.6 GeV and extracted for use on experimental targets. This milestone comes just two years after the groundbreaking for the Tandem/AGS Heavy Ion Project, and a broad array of heavy ion experiments are now underway using the new facility. The first on-line experiment was conducted to measure the total electromagnetic energy produced in the nuclear collisions. More than one-fourth of the total 234 GeV beam energy went into creation of electromagnetic processes. This large transfer of collisional energy into electromagnetic energy means that a huge concentration of "energy density" is created in the nuclear interaction region. These large energy densities provide an entirely new tool for looking at the characteristics of bulk nuclear matter.

After years of development, a new polarized electron beam is now available at the Bates Linear Accelerator Center located at the Massachusetts Institute of Technology. The polarized electron source uses a novel laser technique and was designed and constructed at Yale University for installation at Bates. This device delivers low-energy beams of electrons whose "spins" have been aligned in one direction. The Bates accelerator can then accelerate these polarized beams to high energies without impairing the degree of polarization. The availability of these beams allows the physicists to carry out a whole class of experiments which test basic symmetries of the laws of nature.

A third accomplishment is related to the circular accelerators, called synchrotrons, that require electric power at a changing frequency to take account of the changing velocity of particles in the accelerator. At the Los Alamos Meson Physics Facility (LAMPF) at Los Alamos National Laboratory, a full-sized prototype cavity has been successfully tested using magnetic materials called ferrites for the tuning of a synchrotron accelerating cavity, which is that part of the accelerator mechanism that adds energy to the beam of particles. Using the new technology, it will be possible to provide power more efficiently to future accelerators at the varying frequencies required.

For many years, the Nuclear Physics program operated a chlorine-based solar neutrino detector at the Homestake Goldmine in South Dakota. The very surprising result is that there were only one third as many high energy solar neutrinos detected as were expected. If the deficit is due to a lower number of neutrinos produced in the sun's basic nuclear fusion process, astrophysicists will have to make major revisions in their understanding of solar energy-producing mechanisms. Even more exciting is the possibility that the expected number of neutrinos are produced, but that they change in flight to other types of neutrinos that cannot be seen by the chlorine detector. This transformation depends on recent calculations by Russian and U.S. scientists of a possible "resonant neutrino oscillation" in the core of the sun that would require that neutrinos have a small non-zero mass. The existence of a small neutrino mass would be the first evidence that the Standard Model of fundamental forces is incomplete. More sophisticated solar neutrino experiments are being prepared to test this hypothesis. These experiments will be about one million times more sensitive than ongoing experiments using neutrinos produced in nuclear reactions.

The accelerators used to carry out the experiments I have just discussed, as well as many others, may be divided into energy ranges, each of which is sensitive to the measurement of different features of atomic nuclei. Research in the low energy range helps scientists describe the nucleus in terms of the behavior of its surface (e.g., vibrations, rotations).

Research carried out in this energy region tests to what extent nuclear structure can be described by these simple models. At medium energies, scientists can investigate the behavior of nucleons (protons and neutrons) as constituents of nuclear matter and the role of mesons, which bind the nucleons together. At the highest energies, the research explores the way the internal structure of the nucleons themselves affects nuclear structures, because the high energy reactions can penetrate the underlying quark structure of matter.

The FY 1988 budget request would provide for continued research in each of these energy ranges, with shifting emphasis toward addressing more directly the newest, most fundamental ideas.

FY 1988 NUCLEAR PHYSICS BUDGET REQUEST

The FY 198B budget request for Nuclear Physics is $245.1 million. Of that total, $185.9 million is for Operating Expenses, $17.7 million is for Capital Equipment, and $41.5 million is for Construction (Table 4).

The FY 1988 Operating Expenses request will provide for continued research on the basic properties of nuclear matter, the experi-

Table 4
Nuclear Physics
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses			
Medium Energy Nuclear Physics	$ 73.1	$ 80.9	$ 83.9
Heavy Ion Nuclear Physics	48.8	60.7	65.3
Low Energy Nuclear Physics	20.9	25.4	26.2
Nuclear Theory	9.0	10.0	10.5
Subtotal	$151.8	$177.0	$185.9
Capital Equipment	14.0	15.9	17.7
Construction	6.7	24.1	41.5
Total Nuclear Physics	$172.5	$217.0	$245.1

mental investigation of quarks within nuclei, and the fundamental forces of nature using nuclear matter as a testing ground. In nuclear theory, emphasis will continue to be on understanding the limitations of the present quantum chromodynamics theories of the nuclear force, on improving these theories, and on understanding the ways different quark configurations are revealed in experimental investigations.

The FY 1988 Capital Equipment request for Nuclear Physics is $17.7 million. Capital Equipment funds are needed to provide for particle detection systems, for data acquisition and analysis systems, and for instrumentation to improve performance of Nuclear Physics accelerators. These funds are essential for effective use of the accelerator and detector facilities operated by the Nuclear Physics program. The FY 1988 request is required for projects at Brookhaven National Laboratory, Lawrence Berkeley Laboratory (LBL), Los Alamos National Laboratory, Argonne National Laboratory, Bates Linear Accelerator Center, and Oak Ridge National Laboratory.

The FY 1988 Construction request for Nuclear Physics of $41.5 million (Table 5) includes $33.5 million for the Continuous Electron Beam Accelerator Facility (CEBAF), $4.4 million for Accelerator Improvements and Modifications and $3.6 million for General Plant Projects. These latter projects are needed to maintain the scientific effectiveness, reliability and efficiency of Nuclear Physics facilities.

The construction of CEBAF will address the program's highest priority for new construction. The central instrument of CEBAF will be a modern accelerator with electron beams in the energy range of 0.5 to 4.0 GeV. CEBAF's combination of continuous beam, high current and high energy will be unique in the world and will be important to maintain America's position of worldwide leadership in basic nuclear research. The construction project

Table 5
Nuclear Physics
Budget Authority
($ in millions)

Construction	FY 1988 Request	TEC	Completion Date
Continuous Electron Beam Accelerator Facility (87-R-203)	$33.5	255.0	FY 1993
Accelerator Improvements and Modifications Projects (88-R-201)	4.4	4.4	FY 1990
General Plant Projects (GP-E-300)	3.6	3.6	FY 1990
Total Construction	$41.5		

includes an initial complement of experimental equipment and support facilities necessary to perform scientific investigations using CEBAF's high quality electron beams.

Using recently developed superconducting technology for its accelerating elements, CEBAF will provide beams of unrivaled precision and quality. When CEBAF's energy is at its lowest, the electron beam will interact with the protons and neutrons which are the building blocks of nuclei. When CEBAF's energy is at its highest, the electron beam from the accelerator will probe the underlying quark structures of protons or neutrons, providing a direct test of the newest concepts of nuclear matter. Thus, this facility will provide the world's first access to the critical transition region between the traditional and emerging descriptions of nuclear matter.

When CEBAF is completed, scientists will be able to investigate the ways in which quarks contained in neutrons and protons influence the makeup and behavior of nuclei. Conversely, by determining how quarks interact while embedded in nuclear matter, they will obtain unique tests of quantum chromodynamics as the fundamental theory of the strong nuclear force.

GENERAL SCIENCE PROGRAM DIRECTION

The FY 1988 budget request for General Science Program Direction is $2.8 million. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 39 full-time equivalents in the Office of the Director for High Energy Physics and Nuclear Physics and associated support staff required to administer these programs.

Now let me turn to the Basic Energy Sciences program.

BASIC ENERGY SCIENCES

The U.S. traditionally has been a world leader in science and technology. The basic research activities supported by the Basic Energy Sciences (BES) program are important in order to continue that leadership today. Basic research is the first link in the chain of events from scientific discovery to economic growth through technological innovation. In fact, results from BES-sponsored research become an integral part of the information base used in the development of the applied technologies. In addition to supporting technology development, BES-supported research activities train our future scientists and help us attain our national goals--better health and quality of life, economic competitiveness, energy self-sufficiency, national security--goals calling for significant technological advances.

The BES program supports approximately 1200 research projects annually at over 200 separate institutions. Support is provided to over 1500 researchers in the physical, biological and mathematical sciences. Approximately 67 percent of the program is conducted at national laboratories, including Lawrence Berkeley Laboratory and Ames Laboratory which are both located at universities. An additional 29 percent of the program is carried out at universities throughout the country; and the remainder is conducted by other organizations, including nonprofit institutions and industry.

As a part of its broad scientific research program, BES supports large, state-of-the-art facilities that serve not only the BES program, but also the scientific community as a whole. Industry, university and government researchers have access to these facilities for promising research projects. These facilities are available at no cost to the user if the project is of high technical merit, falls within an area of programmatic interest to BES, cannot be carried out without access to the facility and is not proprietary.

The seven major user facilities are: the High Flux Beam Reactor and the National Synchrotron Light Source at Brookhaven National Laboratory, the Combustion Research Facility at Sandia-Livermore, the High Flux Isotope Reactor at Oak Ridge National Laboratory, the Stanford Synchrotron Radiation Laboratory at Stanford University, the Intense Pulsed Neutron Source at Argonne National Laboratory and the Los Alamos Neutron Scattering Center at Los Alamos National Laboratory. At these major user facilities there were about 1400 users from all scientific disciplines in FY 1986. Their work at these facilities resulted in almost 800 publications, one of the ways in which new research result are disseminated. The activity at these facilities is growing and the number of users is expected to reach 2000 by FY 1988.

While a large percentage of BES research takes place at national laboratories, about one-third of BES funding supports university-based research. Indirectly, however, through the availability of user facilities, laboratory subcontracting to universities, summer programs and laboratory-university relationships, BES support to universities is even higher. An important benefit resulting from supporting research in universities is the research training of graduate students who continue in R&D after completing their studies.

In addition to universities and national laboratories, BES maintains ties with industry. Industrial scientists participate in the review of research proposals and use the specialized facilities supported by BES. Industry representatives also attend BES-sponsored workshops and conferences. Although only a small percentage of BES funds directly supports research at industrial labs, substantial indirect support is provided through the user programs at the laboratories. The user programs make available state-of-the-art research equipment and facilities that are too expensive for any single company to build and operate.

The transfer of new information into technology development and, ultimately, into commercial use is encouraged and assisted in a variety of ways, including publishing research results and co-use of facilities by researchers from university, laboratories and industry. Occasionally, however, technology transfer occurs more directly. A recent example is a new approach to "cryocooling", i.e., cooling matter to very low temperatures, close to absolute zero. Refrigeration to such low temperatures is widely used in the production of liquified gases such as helium, hydrogen, oxygen and nitrogen, but is a highly energy-intensive process. A technique called "magnetic refrigeration" was identified by BES-supported researchers at Los Alamos National Laboratory as a potential way to reduce energy consumption in the refrigeration process. A particularly clever use of the technique was explored over the past few years by this same group of researchers. They constructed a laboratory-scale device that performed so well that the three person group was hired by a manufacturing company to develop a commercial cryocooler based on the principle explored under BES funding. By September 1986, 15 scientists, engineers and technicians were working towards the development of an engineering prototype.

The product of BES-supported research is new fundamental knowledge that underpins the applied technologies related to energy exploration, production, conversion and use. With its long-term focus on new scientific knowledge, ideas and concepts and its unique research facilities, BES is playing a major role in the evolving national goal of enhancing the United States' economic competitiveness with other nations through increased knowledge that can be applied to technology development.

BASIC ENERGY SCIENCES ACCOMPLISHMENTS

While we cannot accurately predict research results or their applications, the following examples of recent accomplishments convey some sense of the breadth of research supported and the potential applications of research results.

- In 1986, the scientific importance of research in chemistry using colliding beams of atoms and molecules, a field pioneered with BES support, was recognized with the award of the Nobel prize to Professors Yuan T. Lee of the University of California, Dudley Herschbach of Harvard and John Polyani of the University of Toronto. Drs. Lee and Herschbach received BES support for this research. By controlling the content and velocity of the colliding beams and the angle at which they approach each other, these scientists found that chemical reactions can in essence be "viewed" as they occur, providing considerable information about their nature and dynamics. Such information should make it possible to manipulate molecules to promote specific reactions from a given combination, opening up a whole new aspect of chemistry.

- While carrying out fundamental studies of the combustion chemistry of nitrogen at the Combustion Research Facility, scientists have developed a process, RAPRENOX, for removal of nitrogen oxide from exhaust gases. Nitrogen oxides are common exhaust emissions that play a major role in photochemical smog and may be important in acid deposition. Preliminary tests demonstrate over 99% removal from the exhaust of a one cylinder laboratory diesel engine. This process should be broadly applicable to other combustion exhausts. A patent application has been filed for the process, and a waiver of patent rights has been granted to the inventor to foster rapid commercialization in the private sector. Industrial funding has already begun.

- At Lawrence Berkeley Laboratory, scientists have developed simple modifications in the process for making steel wire that have resulted in a superior product and reduced production costs. This breakthrough could significantly improve the international competitiveness of U.S. steel speciality products. The combination of high strength, good formability, and improved low-temperature ductility in these wires gives them great potential for such applications as tire cord in steel-belted radial tires. Patents have been awarded, and licensing agreements currently are being arranged.

- Certain plants, in concert with a particular type of bacterium, are capable of taking nitrogen from the air and converting it to a form that satisfies the nutritional requirements for nitrogen that are usually supplied as fertilizer. The genetic activity leading to formation of the nitrogen-fixing root nodules of plants, where the conversion process occurs, appears to be triggered by a naturally occurring compound in the host plant root. Reported in Science magazine late last year, this observation fits into a pattern of recent findings that some unique, relatively simple molecules, including carbohydrates, may be critical in initiating important and complex genetically controlled processes. These types of insights could provide a model for understanding the control mechanisms of other functions critical to disease resistance in plants and regulation of biosynthesis of important plant products, as well as how plants adapt to stress.

- Researchers in the geosciences area recently have found that two narrow beams of high, but different, frequency sound waves interact in rock to produce a narrow beam at a much lower frequency. The new low frequency beam can travel much farther in the rock because of its lower attenuation. This finding offers the possibility of exploring the earth's subsurface more accurately and with greater range.

- Researchers in the biosciences have discovered an enzyme important in breaking down lignin, a major constituent of "woody" plants, and have isolated it from a wood rotting fungus. The "ligninase" gene has been transferred from the fungus to a bacterium, which can produce the enzyme, opening the way for developing organisms with enhanced abilities to break down lignin. This work could lead to commercial-scale methods for converting this abundant renewable resource to chemicals or fuels.

FY 1988 BASIC ENERGY SCIENCES BUDGET REQUEST

The FY 1988 budget request for the BES program is $479.1 million. Of that total, $403.1 million is for Operating Expenses; $31.7 million is for Capital Equipment; and $44.3 million is for Construction (Table 6).

The Operating Expenses request will allow us to conduct an aggressive program aimed at uncovering new energy-related information in materials sciences, chemical sciences, applied mathematical sciences, engineering and geosciences, energy biosciences and advanced energy projects. The request provides for an overall increase of 8.5 percent in the operating budget of the Basic Energy Sciences program to cover cost of living, permit limited expansion in research and cover additional facility requirements (e.g. power, fuel, operating personnel, safeguards and security, safety and maintenance) needed for continued operations.

The Operating Expenses request for the BES program addresses the crucial needs and commitments of the program. Every attempt is made to balance program needs among: the various scientific

Table 6
Basic Energy Sciences
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses			
Materials Sciences	$132.6	155.0	$169.8
Chemical Sciences	104.3	115.1	124.1
Applied Mathematical Sciences	37.4	38.8	40.4
Engineering and Geosciences	25.3	29.4	31.4
Advanced Energy Projects	11.8	12.8	14.3
Biological Energy Research	11.8	16.5	18.6
Program Direction	3.5	4.1	4.5
Subtotal	$326.7	$371.7	$403.1
Capital Equipment	25.6	31.1	31.7
Construction	67.5	122.7	44.3
Total Basic Energy Sciences	$419.8	$525.5	$479.1

disciplines supported by BES; individual scientist and group collaborations; laboratory, university and industry researchers; existing research and new research; and facility support. The request for FY 1988 maintains this essential balance and we believe it will maintain the scientific excellence of the program.

Specifically, the FY 1988 budget will provide the necessary resources to maintain the existing core program in each of the subprograms in BES. In each subprogram a limited number of new research projects can be initiated in those areas that have the highest scientific merit. Also, the budget request maintains the operating funding for each of the BES user facilities to continue operations at planned levels and also meet increased user requirements at the newer facilities, such as the National Synchrotron Light Source and the Los Alamos Neutron Scattering Center.

There are several items in the FY 1988 request which do merit special mention. These items are in our Materials Sciences, Applied Mathematical Sciences and the Energy Biosciences areas. In the Materials Sciences subprogram, a significant commitment is being made to advance R&D in support of and in preparation for construction of the next generation of scientific facilities. These facilities are the 1-2 billion electron volt (GeV) Synchrotron Radiation Source at Lawrence Berkeley Laboratory, the 6-7 GeV Synchrotron Radiation Source at Argonne National Laboratory, and the Advanced Neutron Source at Oak Ridge National Laboratory. These facilities have been identified by the scientific community as crucial to the future needs of the Department's basic research program. As appropriate for each facility, the research dollars being requested allow us to address key scientific issues as well as to define the technical requirements and how to achieve them prior to making final design decisions.

In our Applied Mathematical Sciences subprogram, the request for FY 1988 includes the lease of a new Class VII computer. This computer will be located at the National Magnetic Fusion Energy Computational Center. This new Class VII computer will make available the scientific computing capability required to deal with increasingly complex scientific problems and the rapidly increasing capacity requirements.

The final budget item to be highlighted is the increased funding in the Energy Biosciences subprogram for basic plant sciences research. Funding requested in FY 1988 will provide for the implementation of a research center that will permit detailed structural analyses of complex carbohydrates in plants. These carbohydrates are now known to have crucial regulatory and other functions in numerous biological systems. Without structural information, it is impossible to understand the roles of carbohydrates, which are much more difficult to analyze than proteins or nucleic acids. No U.S. institution with all the requisite instrumentation and expertise currently exists. Many biotechnology applications are also dependent on knowing carbohydrate structural detail. Better understanding of their structure should lead to more innovative and efficient usage of renewable resources.

The Capital Equipment request for FY 1988 is $31.7 million. These funds will assure that BES-supported researchers will continue to have the equipment needed to conduct advanced research. Much of this research involves experiments at extremes of temperature and pressure. Reliable, precise measurements under these conditions challenge the current state of the art. As improvements are made in instruments and equipment, it is important to benefit from them in a timely fashion. The FY 1988 budget request will include such items as high priority synchrotron radiation insertion devices, new equipment for mass spectrometry measurements and enhanced capabilities at the Combustion Research Facility.

The Construction request for FY 1988 is $44.3 million (Table 7). This budget will continue construction of projects underway and will allow initiation of one new construction project. The ongoing projects include the 1-2 GeV Synchrotron Light Source and the Center for Advanced Materials, both at LBL, and the Neutron Scattering Experimental Hall at LANL as well as various accelerator improvements and general plant projects. The new project is the 3 GeV SPEAR Injector at Stanford University.

The Center for Advanced Materials (CAM) project consists of two research laboratories: a Surface Science and Catalysis Laboratory and the Advanced Materials Laboratory. The CAM project will provide the modern tools and facilities required to make major materials advances in energy-related and high technology industries. Its state-of-the-art facilities will be used by scientists to improve our understanding of the underlying chemical and physical phenomena that influence the behavior of materials and the devices of which they are made. Since material problems often stand in the way of technology development, CAM is expected to make major contributions to technological innovation. The FY 1988 budget request of $7.6 million represents the final construction funding for the CAM project which was initiated in FY 1984.

The 1-2 GeV Synchrotron Radiation Source, for which $18.0 million is requested, will provide unique capabilities in the ultraviolet and soft x-ray region of the light spectrum. This frontier facility will open up new research areas in basic and applied science such as materials and surface science, atomic and molecular physics, chemistry and biology.

Table 7
Basic Energy Sciences
Construction Summary
Budget Authority
($ in millions)

	FY 1988 Request	TEC	Completion Date
Center for Advanced Materials (84-ER-112)	$ 7.6	40.2	FY 1988
Neutron Scattering Experimental Halls, LANL (87-R-403)	8.5	17.5	FY 1989
1-2 GeV Synchrotron Source (87-R-406)	18.0	98.7	FY 1992
3 GeV Spear Injector (88-R-403)	3.0	13.5	FY 1990
General Plant Projects (88-R-400)	4.9	4.9	FY 1989
Accelerator and Reactor Improvements and Modifications Projects (88-R-401)	2.3	2.3	FY 1990
Total	$44.3		

Construction funding of $8.5 million is requested to continue construction of the Neutron Scattering Experimental Hall at the Los Alamos Neutron Scattering Center. This project will provide space for experiments and instruments (new spectrometers and data collection computers) required to properly use the unique high flux neutron capabilities at this Center.

Also in FY 1988, we are requesting $3.0 million to start construction of a separate 3 GeV electron injector for the SPEAR storage ring. The injector will allow synchrotron radiation experiments at the Stanford Synchrotron Radiation Laboratory (SSRL) to proceed independently instead of relying on the availability of the linear accelerator at SLAC. Currently, the effectiveness of SSRL for synchrotron radiation research is seriously impaired because of the dependency of electrons from SLAC. Consistent availability of the SPEAR storage ring at SSRL, made possible by the 3 GeV injector, is expected to continue to produce major advances in scientific and technological research along the lines of previous accomplishments such as the development of non-invasive synchrotron radiation angiography, a technique for imaging human cardiovascular systems that poses far less risk than current procedures.

Construction funds also are requested for General Plant Projects and Accelerator and Reactor Improvement and Modifications Projects which are necessary to support the program. The FY 1988 request for these two projects is $4.9 million and $2.3 million, respectively.

The budget request for Program Direction provides for personnel and other costs associated with continuation of 63 full-time equivalents.

This completes my summary of the BES program. Now I would like to turn to the Magnetic Fusion Energy program.

MAGNETIC FUSION ENERGY

The potential of magnetic fusion as a future source of energy is great, and excellent technical progress is being made in this field. The fusion program also contributes to the training of scientists and engineers and to the development of the nation's technological base. Yet, the cost and duration of the program to develop fusion energy discourages private investment. Fusion is, therefore, a clear example of energy research appropriate for the Federal portfolio.

The goal of the program is to establish the scientific and technological base for magnetic fusion energy. The program is being conducted according to the Magnetic Fusion Program Plan (MFPP), which was developed in 1985. This Plan took into consideration the constraints on Federal spending, the uncertainty of energy supply, the excellent technical progress in fusion research, the program's ability to train creative scientists and engineers, the contributions of fusion to basic research in the fields of plasma physics and atomic physics, and the important role of this program in technology transfer to U.S. industry. The Plan also recognized the importance of the Fusion program--a complex scientific effort directed at a practical application. This Plan has been accepted by both the Congress and the technical community.

In this Plan, the timescale for reaching the goal of the magnetic fusion development program is determined by the present technical, economic, and political uncertainties of energy supply. Many of these uncertainties will be resolved within the next fifteen years. It follows that the scientific and technological base required to allow for the practical application of fusion should be in place by the turn of the century.

The strategy for providing this scientific and technological base is twofold: (1) maintenance of a strong, domestic R&D program to adequately cover the necessary range of fusion science and technology issues, and (2) use of international collaboration to advance the program in a timely way. This budget request supports both a strong domestic program and international collaboration, which has become an important facet of the activities associated with the development of fusion energy.

The Fusion program has a long history of scientific exchange and cooperation. The Economic Summit process has provided a mechanism for systematically developing a coordinated fusion program among the summit nations. A great deal of progress toward this goal has been made through the Economic Summit members' Fusion Working Group (FWG). In particular, the FWG deliberations have resulted in the identification of the common mid-term goal of the major fusion research programs, namely, an Engineering Test Reactor (ETR). Most recently, the Reagan/Gorbachev Summits have stimulated the interests of all parties in the prospect of collaborating at least in the conceptual design phase to achieve this common goal.

The Geneva Summit statement advocated the widest practicable development of international cooperation to attain the beneficial use of fusion energy. This intent was reinforced at the Reykjavik, Iceland meeting and resulted in a specific U.S. proposal. The proposal was that the European Community, Japan, the United States, and the Union of Soviet Socialist Republics (USSR) join together to develop a common ETR conceptual design report and to perform the R&D supporting the design within the next three years.

The activity proposed by the United States would prepare any nation or group of nations for subsequent decisions on construction of an ETR. This budget request contains sufficient funding to support the U.S. share of the necessary design work and supporting research and development. The design work will be carried out in a coordinated fashion by comparable design teams working in each nation. The supporting R&D work will be carried out by the parties within their national programs or under existing bilateral and multilateral agreements.

The initiation of an international ETR activity is particularly timely in light of the progress achieved this year in the world's large tokamak experiments. In particular, the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory (PPPL) has set significant new records by reaching reactor-level ion temperatures of 250 million degrees and, in separate experiments, plasma confinement within a factor of two of that required for an ETR. These record achievements are the consequence of the progress made over the past years in solving many smaller, but no less important problems of fusion research. This budget request supports the continuation of a wide range of research that is essential, both for producing continued advances such as the recent TFTR results, as well as for attaining the capability to proceed in the future with more ambitious steps such as the ETR.

TECHNICAL ISSUES

Although magnetic fusion research and development is addressing a wide range of detailed scientific and technological problems, the work supported by this budget request can be summarized in terms of the four key technical issues defined in the U.S. Magnetic Fusion Program Plan. These issues have also been accepted by the Economic Summit members' FWG as the focus for planning future research facilities.

The first of these issues concerns magnetic confinement systems. The particular geometry of the magnetic field used to confine a fusion plasma will have a profound influence on the eventual economics of a fusion device. Therefore, a variety of confinement systems must continue to be investigated at the scientific level. Research on this key issue is being closely coordinated on the international scene to maintain the broadest scientific coverage at minimum cost. This budget request supports the United States' share of research related to: 1) developing the tokamak; 2) participating in an international Stellarator program under the auspices of the International Energy Agency (IEA) and bilateral agreements with Japan and the USSR as well as in a Reversed Field Pinch program under the IEA; and 3) performing smaller scale basic research on the Stellarator and Reversed Field Pinch concepts.

The second key technical issue concerns the properties of burning plasmas. Understanding the properties of burning plasmas is required to complete the scientific base. This step requires a new experimental device that is capable of achieving ignition and plasma burn for the first time. No such experiment currently exists or is under construction in the world. The United States is in the best technical position to proceed with such an experiment.

As part of joint international planning to avoid duplication of costly facilities, the European Community and Japan, through statements by the FWG, have supported the United States' proposal to undertake a Compact Ignition Tokamak (CIT) experiment to provide critical information to support operation of a next step engineering test facility. We expect modest participation from other countries on such an ignition experiment once a commitment to proceed is made. This budget submission contains funding for architect/engineering design and R&D support for the CIT project. The proposed schedule for CIT is determined by both domestic and international program considerations. A timely U.S. CIT will provide vital information on how to operate an ETR in the ignited mode, saving several years of costly exploratory research on the reactor itself. Our ignition experiment should provide this information in the early 1990's to coincide with the plans of the European and Japanese programs and, thus, facilitate international cooperation on the next-step engineering facility.

In order to complete the CIT by the early 1990's, and to make the best use of existing domestic plant and personnel resources, the TFTR facility at PPPL will be used for the CIT. The TFTR experiment will shut down after completion of its scientific program, and the Princeton staff will operate CIT. This budget proposal positions the U.S. to build on experimental progress to date, to use past U.S. investments in facilities and personnel to proceed with its own next step and to support international fusion progress in a major and cost effective way.

The third key issue concerns the nuclear technology of fusion systems. This issue requires advances in engineering sciences, as well as the application of the results of basic fusion materials research. This issue will be resolved only when blankets are tested in a nuclear environment, such as in an ETR. A fusion blanket performs several functions including converting the energy released by a fusion reaction into useful energy, creating part of the fuel for the reactor and allowing for recovery of this fuel, as well as shielding critical components from radiation. As noted above, this budget supports the U.S. share of an international effort on the design and supporting R&D for such an ETR, as well as basic technology research that underlies the development of blankets for the future.

The fourth key issue concerns materials for fusion systems. Since materials play a central role in determining the environmental characteristics of a fusion reactor, they are one of the keys to realizing the benefits of fusion. Achievement of the program goal requires the development of new materials to enhance the economic and environmental potential of fusion, as well as the facilities required for testing these materials. Although of lower near-term priority than the preceding issues, the research needed here requires a long time to complete and must be carried out as part of a complete fusion effort. The proposed FY 1988 budget provides for the core domestic program that supports work in this area. This includes U.S. participation in a coordinated world-wide materials development effort now under discussion within the International Energy Agency (IEA).

In summary, this budget provides for a U.S. Fusion program focused on the key technical issues and interwoven tightly with other world fusion programs through international collaboration. The result is a cost-effective path to the development of fusion energy.

FY 1988 MAGNETIC FUSION ENERGY BUDGET REQUEST

The FY 1988 budget request for Magnetic Fusion Energy is $345.6 million. The request includes $309.0 million for Operating Expenses, $19.7 million for Capital Equipment, and $16.9 million for Construction (Table 8).

The near-term scientific and technological output of the program will be emphasized while we continue to pursue the long-range goal of developing controlled fusion at a pace consistent with our national energy needs. The near-term program achievements also will continue to include the development of well-trained scientists and engineers and the contribution of advanced technology developments which will also prove useful in industrial and defense applications.

The FY 1988 budget request was developed with two major factors in mind. The first is a need to maintain a balance between our domestic science and technology program and foreign programs in order to allow effective international collaboration to supplement our domestic activities. The second is the need to support experimental investigations that are essential to maintain progress. Facilities that are large enough to explore high temperature regimes of plasma physics are required, as well as a number of smaller facilities for investigating key scientific or technology issues on which effective use of the larger facilities depends.

Table 8
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses	$320.5	$319.1	$309.0
Capital Equipment	28.3	18.0	19.7
Construction	12.7	8.2	16.9
Total	$361.5	$345.3	$345.6

The request of $345.6 million includes funds to support an ignition project and the recent U.S. proposal to develop a common international ETR conceptual design as well as the R&D required to support the design. To maintain progress at this level of funding, the program has been narrowed to pursue primarily toroidal confinement systems. In addition, we have identified the highest priority tasks, improved the cost effectiveness of facility operations, and increased the use of international collaboration in all areas. The program will also continue to pursue the four remaining key technical issues--namely, the development of magnetic confinement systems, understanding of scientific principles of a burning plasma, the development of materials for fusion applications, and the development of fusion nuclear technology.

The Magnetic Fusion Energy program is organized into five interrelated functional areas that form the basis for a unified and balanced effort to conduct the research and development necessary to define a practical fusion product (Table 9). The Applied Plasma Physics and Confinement Systems subprograms, working in conjunction, provide the physics base for the Magnetic Fusion Energy program.

The Confinement Systems subprogram, with an FY 1988 request of $170.9 million, supports large-scale physics experiments to address key physics issues associated with heating and containing high-temperature plasma. Confinement Systems also develops an information base on reactor-relevant plasma conditions.

In FY 1988, TFTR will continue to explore breakeven conditions in deuterium plasmas and preparations will continue for deuterium-tritium operation. As part of the US/Japan cooperation program, Doublet III at GA Technologies, Inc., will explore plasma pressure limits with shaped plasmas. Collaboration abroad, especially on European tokamaks, will continue. This collaboration allows the U.S. to gain valuable information while avoiding duplication. In the advanced toroidal area, the PBX at Princeton Plasma Physics

Table 9
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses			
Confinement Systems			
Toroidal Confinement Systems	$142.4	$165.3	$162.0
Mirror Confinement Systems	46.3	21.2	8.9
Applied Plasma Physics	69.7	73.5	73.1
Development and Technology	57.6	50.5	55.9
Planning and Projects	1.0	4.7	4.5
Program Direction	3.6	3.9	4.6
Subtotal	$320.6	$319.1	$309.0
Capital Equipment	28.2	18.0	19.7
Construction			
Compact Ignition Tokamak	0	0	8.0
Mirror Fusion Test Facility-B	3.9	0	0
General Plant Projects	8.8	8.2	8.9
Subtotal	$ 12.7	$ 8.2	$ 16.9
Total	$361.5	$345.3	$345.6

Laboratory (PPPL) and the Advanced Toroidal Facility at Oak Ridge National Laboratory (ORNL) will continue operation. Fabrication of the Alcator C/Modification at the Massachusetts Institute of Technology (MIT) also will continue. This experiment will test recent improvements in tokamak physics design in a high-temperature, high-density, well-confined plasma. The existing Alcator C device will be moved from MIT and installed at Lawrence Livermore National Laboratory for experiments using that laboratory's free electron laser system for heating the plasma more efficiently and for current drive experiments aimed at obtaining a steady state mode of operation. In the tandem mirror area, the Tandem Mirror Experiment/Upgrade at Lawrence Livermore National Laboratory and the TARA experimental program at MIT have been completed. The MFTF-B has been mothballed.

The Applied Plasma Physics (APP) subprogram, for which $73.1 million is requested in FY 1988, develops plasma physics theories and models to predict and explain the experimental and theoretical investigations of basic physics problems related to confinement concepts. APP also develops diagnostic instruments for use by the Confinement Systems subprogram. This subprogram also conducts research on magnetic confinement configurations with potentially improved reactor features and provides the computational support required to carry out the program mission.

In FY 1988 the Applied Plasma Physics subprogram will maintain a core base of research. The two major device fabrication projects that were initiated in FY 1986, the Confinement Physics Research Facility, a reversed field pinch experiment at Los Alamos National Laboratory, and the Field Reversed Configuration Physics experiment at Spectra Technology will be continued. These two experiments will address fundamental physics issues associated with potential improvements to the toroidal confinement configuration.

The Development and Technology subprogram, for which $55.9 million is requested in FY 1988, supports the Confinement Systems subprogram by developing components and systems for use in near- and mid-term fusion experiments as well as long-term generic materials and fusion nuclear technology. This subprogram also performs conceptual design studies for future fusion devices. These design studies identify component and system development needs that must be met to prepare for the eventual application of fusion.

In FY 1988, development of radio-frequency (microwave) heating components tuned to interact with ions (at the ion cyclotron frequency) or with electrons (at the electron cyclotron frequency) will be emphasized. In the magnetics program, the six coil test in the International Fusion Superconducting Magnet Test Facility at ORNL will be completed in FY 1987, increasing our knowledge of superconducting magnet technology. The magnetics program in FY 1988 will turn its focus to the development of high field and pulsed superconducting coils. The ongoing materials program will be maintained at a level to support international collaboration in this area; and small-scale laboratory tests of critical blanket issues will be carried out. Funds are provided to support a U.S. design team that will work with the Summit Nation counterparts on the conceptual design of an international ETR and to perform the necessary R&D required to support the design.

Carrying out the physics and technology research tasks requires the construction of major new facilities in order for progress to continue. The Planning and Projects subprogram primarily provides support for construction of major new facilities and fabrication of auxiliary components for these facilities. The request of $4.5 million supports special program needs and legislative requirements.

The FY 1988 Capital Equipment request is $19.7 million. The requested funds will provide for essential hardware necessary to support the program such as power supplies, diagnostic and computer equipment and components for experimental facilities. The increase in the Capital Equipment request is primarily in the Toroidal Confinement Systems area and reflects the need to partially restore equipment funding to the level needed to support the experimental programs.

The FY 1988 Construction request of $16.9 million provides $8.0 million for the Compact Ignition Tokamak construction project that I discussed earlier in my statement. This project will begin in FY 1988 and will use the existing TFTR facility to minimize costs. A national design team was assembled and has been working for several years to develop a low-cost concept that would meet the requirements of the physics goals for ignition. The project is scheduled to be completed in 1993 at a cost of approximately $357 million. The remainder of the Construction request, $8.9 million, is for General Plant Projects. The projects provide for the continuing minor alterations and modifications necessary to protect the government's investment in its facilities.

The budget request of $4.6 million, for Program Direction provides for personnel and other costs associated with continuation of 62 full-time equivalent staff.

This completes my summary of the Magnetic Fusion Energy program. Now I would like to turn to the Biological and Environmental Research Program.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Department's assigned mission in energy R&D and defense has brought major responsibilities and opportunities in the life sciences. The responsibilities stem from concerns that the energy technologies that contribute to the Nation's well being may also have adverse health and environmental effects. The opportunities arise because many of these same technologies, and the intellectual and physical resources underlying their development, have made major contributions to the health and welfare of society, and hold promise for even greater contributions in the future. Thus, opportunities and dangers are both present; and a central goal of the BER program is to maximize the former while helping to minimize the latter. One of the extraordinary characteristics of the BER program is its comprehensiveness: the global nature of its scope, compelled by its mission, is unique to the nation and perhaps to the world. This breadth makes it ideally suited to carry out highly complex, long-term, multidisciplinary research programs. The BER program has two main objectives: (1) to develop the knowledge base necessary to identify, understand and anticipate the long-term health and environmental consequences of energy use and development; and (2) to use the Department's unique scientific and technological capabilities to solve major scientific problems in medicine and biology.

With regard to long-term health and environmental consequences, BER sponsors research to identify, measure and characterize energy-related contaminants such as radiation and toxic chemicals; to enable us to predict how these chemicals move through and affect the environment; and to understand the potential effects of these contaminants on human health. To do the latter, we must also understand variations in human susceptibility and resistance to environmentally associated diseases and be able to predict the possible genetic burden that current policy places on future generations as well as our own. This is particularly important because so-called heritable mutations often show no visible effects in the current generation even though genetic changes in the DNA molecule have occurred.

The concept underlying the second objective of the BER program mentioned earlier is that the scientific and technological developments spawned by energy research can make major contributions to the study, diagnosis and treatment of human diseases, and to important problems in the biological and environmental sciences. Nuclear medicine is an important example. DOE's capabilities in high energy physics, radiation chemistry, and isotope separation have led to medical advances in the use of a broad array of radioactive and stable isotopes, labeled pharmaceuticals, radiation sources and instrumentation for the diagnosis and treatment of disease. In addition to the obvious direct human benefits of nuclear medicine procedures, these developments have also created a substantial industry that supplies radioisotopes and nuclear medical equipment.

Long-term research in structural biology is also a part of BER's mission. Structural studies provide an understanding of how the functions of proteins, nucleic acids and complex carbohydrates have been genetically encoded in their structures. This knowledge is important not only for understanding how cells are regulated, and thus for understanding the causes of diseases like cancer, but also for the design of drugs and vaccines. Detailed structural studies of these molecules are being conducted at the national laboratories' multi-user facilities such as the National Synchrotron Light Source and the Scanning Transmission Electron Microscope, both at Brookhaven National Laboratory, and the Los Alamos Neutron Scattering Center. The laboratories' advanced computational and engineering capabilities and experience for conducting large collaborative interdisciplinary projects are crucial to the success of this research.

Another research area involves the application of the advanced computational and engineering capabilities of the national laboratories to one of the central objectives of modern biology:

the acquisition and analysis of data on the chromosomal locations and information content of animal and plant genes. As a result of this long-term effort, scientists expect to gain a more complete understanding of the genetic basis for variation in individual susceptibility to environmental agents. This understanding is crucial to being able to predict accurately the effects of low doses of these agents on genetically heterogeneous human populations. Aside from its relevance to DOE's interest in protecting human health from the potential consequences of energy technology developments, this activity promises to provide the basis for major advances in our understanding of human genetic diseases and cancer.

FY 1988 BIOLOGICAL AND ENVIRONMENTAL RESEARCH BUDGET REQUEST

The FY 1988 budget request for the BER program is $217.5 million. Within this request, $205.5 million is for Operating Expenses, $8.5 million is for Capital Equipment, and $3.5 million is for Construction (Table 10). Funding by research area is shown in Table 11.

Research related to the long-term effects of energy development and use on human health and the environment is carried out under four major research areas: Source and Dose Determination, Environmental Processes and Effects, Health Effects and General Life Sciences. Frequently, the results of related research in several of these areas must be considered to understand the long-term effects of a single chemical or technology.

The Source and Dose Determination research activity, with an FY 1988 Operating Expenses request of $16.5 million, will continue to evaluate the extent of exposure of human populations or ecosystems to radiation or chemicals. This activity develops

Table 10
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Operating Expenses	$167.4	$179.5	$205.5
Capital Equipment	7.5	8.5	8.5
Construction	3.1	6.0	3.5
Total	$178.0	$194.0	$217.5

Table 11
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
Late Effects on Health & Environment of Energy Development and Use			
Source and Dose Determination	$ 14.5	$ 13.8	$16.5
Environmental Processes & Effects	29.8	32.1	36.7
Health Effects	57.1	64.8	67.8
General Life Sciences	27.7	29.9	43.6
Nuclear Medicine	22.8	22.1	22.9
Carbon Dioxide Research	12.4	13.2	14.0
Facility Operations	10.6	14.5	12.0
Program Direction	3.1	3.6	4.0
Total	$178.0	$194.0	$217.5

physical and chemical information on energy-related materials released to the environment, as well as the advanced instrumentation needed to evaluate exposure to these materials.

Recent accomplishments in this program area include the development of sensitive, laser-based measurement techniques that are being used to trace hazardous materials through the environment and to date environmental samples. Researchers also have developed several practical monitoring devices for hazardous chemicals that are now being exploited commercially. For example, a portable system which can detect up to 40 individual gases and sound a warning if levels are too high protects firefighters from toxic vapors in smoke. In the area of radiation health effects, more accurate calculations of radiation doses to the Japanese A-bomb survivors have been provided to the Radiation Effects Research Foundation in Hiroshima, Japan. These new data will allow a better evaluation of the health effects of radiation exposure.

In FY 1988, this program area will emphasize radiation measurement and characterization activities. An expanded effort will address radon in indoor air. Specifically, research will focus on the radiation dosages from radon and its decay products and on radon's potential effect on critical cells in the respiratory tract. Research on chemical dosimetry, which is the measurement of doses of chemicals to parts of the body, also will be pursued, with emphasis on chemically altered DNA.

The FY 1988 Operating Expenses request for the Environmental Processes and Effects research activity is $36.7 million. This comprehensive program in the physical and ecological sciences focuses on pathways and mechanisms by which energy-related substances move through and affect the atmospheric, marine and terrestrial environments.

Atmospheric research is carried out through laboratory research as well as under two major field programs: PRECP (Processing of Emissions by Clouds and Precipitation) and ASCOT (Atmospheric Studies in Complex Terrain). The goal of the PRECP program is to develop a quantitative understanding of the physical and chemical processes that incorporate and transform atmospheric pollutants into clouds and storms and remove them through precipitation. Five field experiments have been conducted thus far; and scientists have gained important information about the transport of pollutants in the atmosphere. In FY 1988, PRECP will conduct the sixth major field experiment. This study will evaluate the processing of acidic pollutants by East Coast storms.

Scientists have already learned much about the processes responsible for dispersing atmospheric pollutants over complex, mountainous terrain through the ASCOT program. This information is valuable in siting energy facilities, improving emergency response procedures, and understanding the newly discovered mountain-plains circulation patterns which have direct application to emergency response procedures as well as to the day-to-day operations of pollutant-emitting energy facilities. In FY 1988, transport and dispersion research under ASCOT will be extended to multiple valley systems and will begin to evaluate a previously unsuspected circulatory pattern over the western mountains that was discovered as a result of previous ASCOT research.

Scientists also have made significant progress in controlled laboratory experiments aimed at understanding the chemical processes of acid rain generation. It is expected that this new information on the importance of hydrogen peroxide as a key oxiding agent will greatly enhance the acid deposition assessment activity carried out under the National Acid Precipitation Assessment Program.

In FY 1988, marine research, which is carried out in three regional coastal areas, will continue to focus on the way in which radionuclides and other energy materials move through the ocean and on their ultimate fate in the ocean. Since substances move from disposal sights to distant locations, knowledge of their migration patterns and rates of movement is crucial to making informed choices for disposal sites. The knowledge of coastal currents gained in this basic research program recently proved useful in locating the Challenger booster rocket and other debris.

In addition to atmospheric and marine research, this activity will continue to support research aimed at improving our understanding of the processes that control and affect the transport of chemicals in the subsurface environment. In FY 1987, research was initiated to investigate the presence of microbial populations in deep aquifers. Early results have shown a surprisingly high level of microorganisms at depths down to 900 feet. In FY 1988, a greater effort will be made in microbial ecology to understand and exploit natural mechanisms to degrade chemical contaminants, thus eliminating or reducing their harmful effects. This research will have long-term implications for decontamination of deep aquifers.

The FY 1988 Operating Expenses request for Health Effects research is $67.8 million. Health effects research evaluates the effects on workers and the general public of exposure to energy-related environmental agents, such as radiation and toxic chemicals. The research focuses on two primary areas of study. The first is the epidemiological investigation of human populations who have been exposed to specific toxic agents. In this research, scientists analyze the health effects of acute exposures, such as in the case of atomic bomb survivors in Japan, and chronic exposures, like those incurred by the uranium mine workers in New Mexico.

In addition to epidemiological studies, controlled experiments are conducted in which animals, animal organs, and animal and human cells are exposed to a toxic agent and examined to determine how they were affected by that agent. The resulting data provide valuable information on the effects caused by chemical and radiation exposure at levels of biological organization ranging from the molecular level to the whole organism. The data also help scientists learn how effects at different levels are interrelated. In addition, data from basic research helps investigators learn more about the mechanisms governing genetic and other biological damage in animals and, ultimately, in humans.

Several activities are underway in this second area of research. In FY 1988, a strong program of research to increase our understanding of the biological actions of neutrons and alpha radiation, both of which are associated with nuclear energy systems, will continue. Researchers are trying to understand why radiation from neutrons and alpha particles is more effective in producing biological responses than are x-rays and gamma radiation. One study will seek to determine if the high relative biological effectiveness of neutrons can be accounted for by differences in the pattern of radiation dose that is delivered by the three types of radiation to individual target cells in body tissues. Studies of the repair of DNA damage caused by neutrons and alpha particles also will be continued.

A significant increase is projected for research to define health risks associated with human exposures to radon and its radioactive daughter products, which are natural components of indoor air. A basic research approach is being taken in this effort that includes research to determine which of the many different cell types in the respiratory tract is the critical target of radiation from radon and its daughters and how target cells respond to radiation. One element of this research will address the chemical and radiological interactions in the respiratory tract between radon and other inhaled pollutants. This research is aimed at evaluating DNA repair activity and determining if the presence of active cancer-causing genes can be detected.

Research in the General Life Sciences, for which $43.6 million is requested in FY 1988, contributes to the base of fundamental biological knowledge necessary to study and interpret energy-related health effects. This activity includes research on the structure and function of genes, the arrangements of genes on chromosomes, and the effect of the location of genes on regulation and expression. This information is important since many debilitating diseases are the result of faulty gene regulation or expression. Researchers working in the area of genetic control of biological processes have shown that a gene that mutates easily is in part responsible for facilitating genetic rearrangements that result in specific immune responses. In a related finding, researchers have determined that active cancer-causing genes are present in malignant tumors resulting from low-level ionizing irradiation of dogs. Other BER-supported investigators have for the first time isolated a gene that is responsible for the repair of ionizing radiation damage in the DNA of human cells.

The structural biology activity under General Life Sciences will receive increased emphasis in FY 1988. Most of this activity revolves around unique multi-user facilities such as the National Synchrotron Light Source, various reactors and accelerators, and the powerful computers of the national laboratories. With the aid of these resources we now have the ability to determine the structure of giant biological molecules many times more rapidly than in the past. This knowledge is important, not only for understanding how cells are regulated, and thus what causes many diseases, but also for the rational design of drugs and vaccines. In FY 1988, the development of advanced instrumentation at the National Synchrotron Light Source will make it possible to do studies of biological processes that are time dependent. Structural studies will be expanded at the Los Alamos Neutron Scattering Center and we will place increased emphasis on the development of computational methods to relate the linear sequence of amino acids in protein molecules to their three-dimensional structure. Information gained from this research will help scientists understand the relationship between the structure of giant biological molecules and their functions.

Another research activity that will receive increased emphasis in FY 1988 is the application of the advanced computational and engineering capabilities of the national laboratories to one of the central objectives of modern biology: the acquisition and analysis of data on the locations of chromosomes and the information content of human genes. Phase I of the National Laboratory Gene Library Project, which makes available large purified quantities of each of the human chromosomes, was completed in 1986. DNA fragments with average lengths of 4000 bases, which are individual chemical units, have been prepared from all human chromosomes and placed in an NIH-funded repository for distribution to the scientific community. In phase II, which is now underway, fragments having average lengths of 40,000 bases (about the size of a single gene) will be prepared. To put that number in perspective, a single chromosome could have 100 million bases; and the human genome, which is the complete set of genetic instructions for a human being, is comprised of about three billion bases.

The FY 1988 Operating Expenses request for Nuclear Medicine is $22.9 million. Nuclear medicine has provided non-invasive methods for monitoring body functions, isolating and treating the causes of diseases, and identifying anatomic and functional abnormalities in ways never before possible. The results of this research have led to widespread use of nuclear technology in clinical and laboratory medicine. An estimated 80 to 100 million nuclear medicine procedures are performed annually in the U.S.; and nuclear medicine has spawned industries valued at hundreds of millions of dollars a year.

Recent accomplishments include the development of heavy ion beams to treat life-threatening vascular disorders of the brain that are inoperable or inaccessible, and development and testing of a new technetium-99m labeled agent to measure blood flow in patients' heart tissue. This latter technique has excellent promise for evaluating heart tissue damage following a heart attack. A major new breakthrough in the detection of human brain tumors was made with the completion of eight pilot studies of cancer patients using a new tracer and a technique called positron emission tomography (PET). Also, by means of PET, the ability to measure biochemical processes non-invasively has resulted in the unique opportunity to study the response of the human brain to drugs and to a variety of behavioral tasks. In addition, a method for differentiating between mild cardiovascular disease and more severe heart tissue damage was demonstrated which promises to improve the criteria for selecting patients who can benefit from bypass surgery.

In FY 1988 this research activity will continue to develop and apply new non-invasive techniques and radiopharmaceuticals for research on and diagnosis and treatment of diseases. The activity also will increase the number of patients with malformations of the cerebral circulatory system to be treated with heavy ions (heavier than helium) and will explore the possibility of applying radioactive beam techniques to the measurement of cerebral blood flow following irradiation, thus allowing measurements of the effectiveness of the treatment. Research in FY 1988 will also include tests on the feasibility of boron neutron capture therapy for treatment of aggressive brain tumors and other cancers.

The goal of the Carbon Dioxide Research activity, for which $14.0 million is requested for FY 1988, is to develop sound, quantitative information about atmospheric CO_2 change and its effect on climate, earth resources and energy requirements. It is essential that we understand cause and effect relationships between CO_2 concentrations and global warming before energy policy recommendations are made that could influence future generations profoundly. DOE recently completed a comprehensive evaluation of scientific information surrounding the CO_2 problem by publishing a series of State-of-the-Art Reports. These reports show substantial progress toward scientific understanding of the CO_2 greenhouse problem, and they have been well-received internationally. Yet they also show that further research is needed to reduce uncertainties, and to provide a factual basis for intelligent decisionmaking.

The first research need is to document how climate is changing and to confirm that the changes are consistent with projections. There is now substantial disagreement among climate model forecasts; and the models must be compared to observed data and to one another to understand where and why the models agree and disagree. The results of this research, which will receive high priority in FY 1988, will improve climate models and, thus, our ability to estimate regional climate change.

In addition, substantial improvement is needed in the way oceans and clouds are portrayed in climate models. In FY 1988 there will be increased emphasis on understanding how oceans affect global exchange and storage of CO_2 and heat. This will be accomplished with improved ocean circulation models, and through close coordination with international oceanic research carried out through other agencies including the National Science Foundation, the National oceanographic and Atmospheric Administration and the National Aeronautics and Space Administration. Two of the key programs expected to produce important data are the Tropical Oceans and Global Atmosphere (TOGA) project and the World Ocean Circulation Experiment (WOCE).

Another problem identified by the State-of-the-Art Reports is the need to develop data and evaluate the primary effects of both CO_2 and climate change on biological systems as a whole. The main objective is to establish the knowledge base for evaluating changes in biological systems, for example, changes in productivity, water-use and the synergistic relationships among plants, animals and microbes. The research focus in FY 1988 will be on agricultural systems and natural ecosystems. The activity also will carry out research aimed at developing scientifically-based information on the effects of these changes on such factors as crop yields and the productivity of ecosystems. This information, in turn, will be used to evaluate potential effects on resources used by man.

The FY 1988 budget request for Facility Operations for the BER program is \$12.0 million. Of this total, \$8.5 million is for Capital Equipment and \$3.5 million is for General Plant Projects. The ability to address diverse health and environmental issues requires a continued commitment to maintaining advanced instrumentation and facilities. The Capital Equipment request supports replacement of deteriorated and obsolete equipment at the laboratories as well as acquisition of new, state-of-the-art instruments. General plant projects are necessary to accommodate continuing requirements to maintain satisfactory and economical operating conditions, to meet regulatory requirements and to support new programs.

The FY 1988 request for Program Direction is $4.0 million. These funds are required to pay for the personnel costs of 53 full-time equivalents to direct, manage and support BER's multidisciplinary research efforts.

This completes my summary of the BER program. Now I will turn to the several ER outlay programs that are related to my statutory responsibilities to advise the Secretary on DOE's R&D programs, on the non-weapons multiprogram laboratories and the education and training of scientists and engineers.

ADVISORY AND ASSESSMENT ACTIVITIES

The Office of Field Operations Management (FOM) and the Office of Program Analysis (OPA) support the Director of Energy Research's statutory advisory responsibilities. The Office of Field Operations Management provides support with regard to management oversight of the laboratories and the energy-related manpower development and training activities of the Department. The Office has developed policies and management tools that the Department uses to administer its labs and R&D facilities across the country. The Office also manages the University Research Support, University Research Instrumentation and Multiprogram Energy Laboratories-Facilities Support programs, each of which I will discuss shortly. The Energy Research Analysis program, managed by the Office of Program Analysis (OPA) provides independent and objective program analyses and technical assessments.

ENERGY RESEARCH ANALYSIS

The Energy Research Analysis (ERA) program provides support to the Director in fulfilling his responsibility to advise the Secretary on the Department's scientific and technological research programs and on potential duplications or gaps in such programs.

Thus, one of the program's principal tasks is to support technical reviews of DOE's research programs by expert scientists. The judgments expressed by these expert scientists lead to recommendations on the necessary next steps for ongoing and planned research. Altogether, several hundred industry, academic and laboratory researchers participate in the technical reviews and program assessments. Another important function of the ERA program is to assess and document the important scientific accomplishments and societal benefits resulting from the Department's research programs.

Recent accomplishments related to the technical and program assessments carried out by this program include a technical assessment of coal gasification research needs as viewed by leading scientists and engineers from industry and academia. Separate assessments of the significant research accomplishments of one of DOE's exploratory R&D programs and some of the most significant accomplishments of the Magnetic Fusion Energy program also were completed.

The other major ERA activity is in the area of acid rain. DOE is one of the five funding agencies of the National Acid Precipitation Assessment Program (NAPAP). This program provides DOE's share of the financial support for management of NAPAP which was created by the Acid Precipitation Act of 1980 (P.L. 96-294). The program provides funds under NAPAP for summarizing and synthesizing the state of the science in acid rain research and producing assessment reports useful for policymakers and resource managers. The Office of Program Analysis represents DOE on technical task groups and critiques documents produced by both NAPAP and non-Federal groups for their scientific quality and objectivity.

This role has evolved in part because the Department brings to the interagency effort a unique and extensive background in several areas that are especially important in the study of acid deposition, including atmospheric, ecological and biological sciences.

The FY 1988 budget request for Energy Research Analysis is $3.7 million. This budget request will permit completion of a report in FY 1988 on the accomplishments of the Department's High Energy Physics program over the last 30 years. The FY 1988 request would also allow an analysis of the accomplishments of the Advanced Research and Technology program under the Office of the Assistant Secretary for Fossil Energy. In addition, in-depth technical peer reviews will be prepared on two major Fossil Energy research programs, Advanced Process Technology and Fossil Energy's Small Business Innovative Research. Research needs assessments will be carried out in the areas of Coal Liquefaction, Mixed-Wastes (i.e., radioactive and toxic wastes), and Materials by Design. A new class of peer reviews will be performed in FY 1988 with the review of the exploratory R&D programs at each of the national laboratories for which the Office of Energy Research has oversight responsibility--Argonne, Oak Ridge, and Brookhaven National Laboratories, Lawrence Berkeley Laboratory and Pacific Northwest Laboratory. Also in FY 1988 technical studies will be conducted to support the NAPAP Second Interim Assessment, due in 1988, which will synthesize the results of $300 million worth of Federal acid rain research.

UNIVERSITY RESEARCH SUPPORT

A strong scientific and technological base is crucial to both national security and economic growth. This base, in turn, is heavily dependent on a healthy university system capable of producing both new scientific knowledge and new technical talent.

DOE support for university research is an essential investment in the future. This support is provided through research grants and contracts with university scientists and through use of unique laboratory research facilities and resources by university faculty and students.

The three primary objectives of this support are to:

- strengthen university capabilities to perform long-range R&D;
- enhance the quality and increase the numbers of young people interested in pursuing energy-related careers; and
- take full advantage of the unique resources and facilities at the DOE national laboratories for university faculty and student research and training.

The University Research Support (URS) program and the related University Research Instrumentation (URI) program, which I will discuss next, are the most direct approaches used by DOE to strengthen the institutional capabilities of universities and colleges to contribute to the Department's long-term R&D mission. The URS program, with an FY 1988 budget request of $13.4 million, consists of three activities: University Laboratory Cooperative Research, for which $9.8 million is requested; University Reactor Fuel Assistance, with a request of $1.9 million; and Energy Manpower Development, for which $1.7 million is requested (Table 12).

In FY 1988, the University Laboratory Cooperative Research activity will continue to provide support for faculty and student research and training appointments at the DOE laboratories. More specifically, the FY 1988 budget request will increase the number of faculty and student research participants by approximately 10 % over the FY 1987 level. In addition, an expansion in this program area is proposed through the initiation of support for semester-length research appointments at five multiprogram laboratories. The very best undergraduate science and engineering students will be chosen to participate nationally at these science centers. The appointments would be made following

Table 12
University Research Support
Budget Authority
($ in millions)

Operating Expenses	FY 1986 Adjusted	FY 1987 Conf. Approp.	FY 1988 Request
University Laboratory Cooperative Research			
Center for Excellence in Education at Indiana University	$ 5.7	$ 6.8	$ 9.8
University Research Fuel Assistance	--	3.8*	--
	3.7	3.9	1.9
Subtotal	$ 9.4	$14.5	$11.7
Energy Manpower Development			
Energy Manpower Assessment	$ 0.4	$ 0.5	$ 0.5
Energy Education & Training	0.4	0.8	1.2
Subtotal	$ 0.8	$ 1.3	$ 1.7
Total	$10.2	$15.8	$13.4

*Proposed for rescission by the Administration.

a national announcement and selection. During the appointment period, the participants will be involved in research on a specific project in collaboration with laboratory scientists and visiting university faculty. They would also receive hands-on experience with major, state-of-the-art scientific research instrumentation. Approximately 200 undergraduate students will receive such appointments at 5 ER laboratory science centers. This effort is designed to utilize more completely the unique physical and human resources at the DOE laboratories to assist in improving the quality of the nation's scientific and technical education.

The University Research Support program also will place increasing emphasis on technology transfer through the laboratory-industry technology exchange program. In FY 1988 there will be approximately 15 visiting industry scientist and engineer appointments at DOE's laboratories. These industry representatives, who will participate on a cost-sharing basis, will work side-by-side with DOE-supported researchers to transfer laboratory expertise to commercial application. Support will also continue on approximately three generic or pilot laboratory initiatives to improve "spin-off" of federally-funded R&D to U.S. industry and on preparation of the R&D laboratory technology transfer report.

The University Reactor Fuel Assistance subprogram provides support for refueling and related activities for university nuclear research and training reactors. This activity also includes support on a competitive basis for university reactor sharing grants which provide research and training opportunities for faculty and students from nearby universities and colleges. In FY 1988, this activity will fund 20 reactor sharing grants involving scientists from 50 colleges and universities. The requested funding would also allow refueling of seven university reactors. The low enriched uranium (LEU) reactor fuel conversion program required by the Nuclear Regulatory Commission will be approximately at its midpoint by FY 1988 with twelve university reactors having received support for their reactor safety studies and three having received approval from the Nuclear Regulatory Commission for final conversion to LEU fuel.

The third URS program activity, Energy Manpower Development, includes efforts directed both at increasing the number of young people pursuing energy-related scientific and technical careers as well as enhancing the quality of the scientific education received by these very bright students. This activity also includes the Department's statutory responsibility for assessing the supply of and demand for manpower for current and future energy R&D programs. The FY 1988 budget request of $1.7 million for this activity includes expanded support for high school science student and teacher programs sponsored through the DOE laboratories. In FY 1987, honors programs are being sponsored at four laboratories. In FY 1988, high school science student honors programs will be supported at five laboratories: Lawrence Livermore, Brookhaven, Lawrence Berkeley and Oak Ridge National Laboratories and Fermi National Accelerator Center. Students will be selected for participation in these programs by the Governors of all states plus Puerto Rico and the District of Columbia. Similar honors programs sponsored in FY 1985 and FY 1986 received national visibility and acclaim as excellent approaches toward exposing the very best high school science students to the world-class research facilities and programs at the DOE labs.

UNIVERSITY RESEARCH INSTRUMENTATION

Advanced scientific and technical research requires advanced instrumentation. The state-of-the-art of scientific research instrumentation (along with the purchase price), however, has increased so rapidly in the last five years that major research instruments can be obsolete in three to five years. Since research equipment generally is used by many scientists, the effect of obsolete or over-utilized equipment is magnified. For example, a nuclear magnetic resonance spectrometer at Purdue University serves 270 researchers in an around-the-clock operation. Lack of up-to-date facilities affects not only the production of research results, but also the training received by graduate students. Since the majority of university graduate students are employed by industry, industrial scientists need to spend an inordinate amount of time training new staff in the use of advanced instrumentation, clearly with a negative effect on industrial research productivity. The seriousness of the problem has been confirmed by a variety of Federal and private studies.

The primary objective of the University Research Instrumentation (URI) program is to strengthen the capabilities of university scientists to conduct advanced research on energy problems and processes. A secondary objective is to provide graduate students with first-hand experience in the use of sophisticated research instrumentation. The URI program complements the Department's energy research and technology programs. Generally, research grants and contracts provide support only for research operating cost (salaries, computer time, etc.) with funding for new equipment limited to instruments costing under $30,000. The URI program assists universities in purchasing instruments costing over $100,000 that will be used by a number of researchers, including students.

The program is a competitive one involving considerable cost sharing by the institution receiving the award. Awards are based on the merit and the accomplishments of current DOE-supported research projects and the degree to which the new equipment will enable researchers to substantially advance the understanding of energy-related phenomena. A total of 70 awards have been made in the last three years, ranging from $98,000 to $466,000.

In the four years since its inception, the program has given special attention to advanced scientific equipment for research in such areas as metallurgy, ceramics, solid state materials, heat transfer, bioconversion, atmospheric pollutants, combustion and nuclear waste isolation research. In FY 1988 special emphasis will be given to proposals for "innovative" instrumentation that is not generally available at U.S. universities.

MULTIPROGRAM ENERGY LABORATORIES--FACILITIES SUPPORT

The goal of the Multiprogram Energy Laboratories--Facilities Support (MEL-FS) program is to maintain the capabilities of the five national laboratories supported by Energy Research: Argonne, Brookhaven, Lawrence Berkeley, Oak Ridge and Pacific Northwest laboratories. This is done by supporting activities and projects which counter the problems of aging and obsolescence of facilities and of environmental compliance. These labs performed over a billion dollars worth of research for the Department in FY 1986. The productivity of their work force of over 17,000 scientists, engineers and other support staff is greatly affected by the adequacy of the laboratories' facilities.

The FY 1988 budget request for MEL-FS is $56.6 million (Table 13). Of that amount, $30.5 million is for the General Purpose Facilities Construction subprogram which originated in FY 1981 as a broad program for rehabilitation, upgrade or replacement of deficient buildings, utilities, roads and other necessary facilities at the laboratories supported by ER. The Construction request for this subprogram (Table 14) will continue 14 previously started projects and provide for nine new starts, including five environmental-related projects, one fire safety project, two utility upgrade projects and one building rehabilitation project.

The remainder of the FY 1988 budget request ($26.1M) is for the

Table 13
Multiprogram Energy Laboratories-Facilities Support
Budget Authority
($ in millions)

	FY 1986 Actual	FY 1987 Conf. Approp.	FY 1988 Request
Multiprogram Energy Laboratories-General Purpose Facilities			
Construction	$22.8	$31.4	$30.5
Environmental Compliance			
Operating Expenses	9.4	14.3	12.9
Capital Equipment	1.0	1.0	0.4
Construction	6.7	10.0	12.8
Subtotal	$17.1	$25.3	$26.1
Total MEL-FS	$39.9	$56.7	$56.6

Table 14 (continued)
Multiprogram Energy Laboratories-General Purpose Facilities (MEL-GPF)
Budget Authority
($ in millions)

Construction	TEC	FY 1988 Request
Prior Year Ongoing Projects		
Upgrade Steam Distribution System, ORNL (87-R-759)	6.8	5.5
Rehabilitate Mechanical Utilities, LBL (87-R-758)	5.5	3.0
Electric System Rehabilitation, LBL (87-R-757)	2.6	2.3
Water Line Replacement, ANL (87-R-756)	5.2	2.0
Mechanical System Rehabilitation, ANL (87-R-755)	3.2	2.1
Rehabilitate Laboratory Space, ANL (87-R-753)	12.0	3.6
Piping System Restoration, ORNL (87-R-752)	3.8	3.1
Fire Protection Improvements, BNL (86-R-726)	3.0	0.4
Central Chilled Water Plant, ANL (85-R-709)	5.2	0.6
Hanford Site Fire Alarm System Upgrade, RL (85-R-707)	4.9	0.6
Medical Facilities, LLNL (85-R-706)	7.3	0.2
Replace Laboratory Roofs, ANL (85-R-702)	8.9	0.3
Central Chilled Water Facility, BNL (85-R-701)	15.0	0.3
Road Repairs, INEL, LBL, RL, ANL (84-ER-103)	17.8	0.5
Subtotal Ongoing Projects		$24.5
Total MEL-GPF		$30.5

Table 14
Multiprogram Energy Laboratories-General Purpose Facilities (MEL-GPF)
Budget Authority
($ in millions)

Construction	TEC	FY 1988 Request
New Projects		
Upgrade Fire Protection, ORNL (88-R-817)	$ 1.8	$ 0.8
Sanitary Sewage Treatment Facility, PNL (88-R-814)	3.0	1.0
Hazardous Waste Handling Facility, LBL (88-R-812)	4.6	0.5
Plant Modifications to Comply with EPA Requirement, ANL (88-R-809)	1.8	0.8
Electrical System Rehabilitation, ANL (88-R-807)	5.1	0.5
Environmental Health and Safety Project, LBL (88-R-806)	10.3	0.8
Environmental Improvements, BNL (88-R-805)	4.0	0.6
Piping Systems Upgrade, ORNL (88-R-804)	1.9	0.5
Laboratory Building Rehabilitation, BNL (88-R-802)	1.9	0.5
Subtotal New Projects		$ 6.0

Oak Ridge National Laboratory (ORNL) Environmental Compliance subprogram. The subprogram originated in FY 1985 to address non-defense environmental deficiencies at ORNL. Since the early 1940's, ORNL has generated a variety of radioactive and nonradioactive pollutants which were handled in accordance with environmental regulations existing at that time. Since then, a number of new regulatory requirements have resulted in the application of more stringent environmental criteria. This subprogram will help bring all past and present systems up to current environmental standards, performing remedial actions related to past Energy Research activities where necessary. The FY 1988 request for this subprogram includes the final funding increment for the Non-Radiological Processes Waste Treatment project and initiation of the Low-Level Waste Collection and Transfer System Upgrade project. The latter replaces underground radioactive transfer lines and holding tanks that no longer meet current environmental standards. The ORNL environmental clean-up is also supported by Defense Programs.

The FY 1988 budget request for Advisory and Oversight Program Direction is $3.2 million. The FY 1988 request will provide the staffing resources required by the Director of Energy Research to carry out his responsibilities under legislation (P.L. 95-91) and those assigned or delegated by the Secretary in areas beyond the scope of other ongoing Energy Research programs. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 44 full-time equivalents.

The FY 1988 budget request for Policy and Management is $0.6 million. These funds are requested to provide for the salaries and related expenses associated with 8 full-time equivalents in the Office of the Director of Energy Research.

That concludes my prepared statement. I would be happy to answer any questions at this time.

Environment, Safety, and Health Program

STATEMENT OF MARY L. WALKER, ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY, AND HEALTH

Senator Johnston. Go ahead, Ms. Walker.

Ms. Walker. My full statement, I would like entered into the record, but just briefly to highlight some things for you.

Last year when I was here, I outlined Secretary Herrington's initiatives to strengthen the environment, safety, and health function within the Department of Energy, and his personal commitment to assure safety and environmental excellence at our facilities and our operations. I wanted to let you know today that we have made substantial progress to carry these out.

REORGANIZATION IN PLACE

The reorganization is in place. We have a stronger organization, with considerably more personnel with experience, especially in the environmental area, and certain areas in safety committed to the oversight function.

We have already begun performing the Environmental Surveys and the Technical Safety Appraisals. Those actually began at about this time last year, and they are continuing to proceed and are producing results. We have the Computer Assisted Tracking System in place that is already tracking corrective actions.

Finally, the Environmental Issues Coordination process that the Secretary set up so that we would be able to speak with one voice in the Department and resolve environmental issues as they were raised at the operations level; that is also working.

As a result of those issues and other areas where we have identified environmental compliance problems in our system, we have entered into a significant number of federal facilities compliance agreements with EPA and the states which assure that our facilities are brought into compliance as we want them to be.

We believe the fiscal year 1988 request of $70 million will help us continue this oversight effort. It represents an $8 million increase over fiscal year 1987 and primarily that is for three areas: The Environmental Audit Program that will follow the Environmental Survey, its development; the safety analysis reports that are being prepared for our facilities in the high and moderate hazard area, and in others. We will be participating directly in the evaluation of those as an independent oversight function, especially the high-hazard facility area. Last, the salaries and benefits for the increased personnel in our Office.

I would like to thank you and members of the committee for your support in this important effort. We appreciate that you have supported us in the critical efforts that the Secretary of Energy has undertaken.

Thank you.

[The statement follows:]

STATEMENT OF MARY L. WALKER

Mr. Chairman and Members of the Subcommittee, I am pleased to be here today to discuss with you the Department's budget request for FY 1988 for the Environment, Safety and Health Program.

GOALS OF THE OFFICE OF ENVIRONMENT, SAFETY AND HEALTH

It is the policy of the Secretary of Energy to conduct all of the Department's operations in a safe and environmentally sound manner. Protection of the environment, our workers and the public are of paramount concern and importance to the Department.

The goals of the Environment, Safety and Health program are to:

- Provide clear guidance to Field Organizations and Headquarters Program Offices on environment, safety, health and quality assurance policy, standards and compliance requirements.

- Assure and demonstrate, through effective oversight, conformance of the Department's activities with applicable policies, standards, laws and regulations and assure that the health and safety of workers and the public are protected.

- Provide liaison with other Federal agencies, such as the Environmental Protection Agency, concerning regulatory efforts and specific actions of those agencies that may have an impact on the Department's operations.

- Assure that national environmental protection goals are incorporated into the formulation and implementation of energy programs and policies.

- Develop policy options for the Department on the effects of national environmental policy and regulations on U.S. energy industries and energy supply and demand.

Three long-range strategic objectives have been established to focus program activities on accomplishment of these goals;

- Complete work on the Department's Environment, Safety and Health initiatives.

- Improve environment, safety and health policy, guidance and standards.

- Strengthen and make more effective environment, safety and health oversight of DOE facilities.

STATUS OF ENVIRONMENT, SAFETY AND HEALTH INITIATIVES AND OTHER RELATED DEVELOPMENTS

FY 1988 will be the third full year of implementation of the Environment, Safety and Health initiatives announced by the Secretary on September 18, 1985. I am pleased to report sustained progress on each of the initiatives. These initiatives were ordered to strengthen the Environment, Safety and Health Program within the Department. While certain of the stated goals of the initiatives are not yet fully accomplished, the progress we are making has already placed the Environment, Safety and Health Program on a more sound, more disciplined and more informed basis. The initiatives are comprised of five major elements:

1. The reorganization of Environment, Safety and Health under a new position of Assistant Secretary for Environment, Safety and Health.
2. The Environmental Survey.
3. Technical Safety Appraisals.
4. The Computer Assisted Tracking System.
5. The Environmental Issues Coordination Process.

The reorganization initiative is intended to add professional and functional strength to the office. Consolidation of scattered oversight elements within the Department has been accomplished. A balanced management and functional structure has been put in place and additional resources have been allocated to carry out the expanded role for the Environment, Safety and Health Program.

The Environmental Survey of all Departmental sites, the most significant initiative from the standpoint of resource requirements, is being conducted to identify environmental problems and areas of risk, and to prioritize those for corrective action. This program has proceeded steadily and has met every expectation to date. As of December 1, 1986, on-site Environmental Survey work has been completed for 8 of the larger DOE sites. Under the current schedule, 20 sites will be completed in FY 1987, 16 sites in FY 1988, and completion of the Survey and a final report to the Secretary will occur in FY 1989.

Another significant initiative is the Technical Safety Appraisals of the Department's high and moderate hazard nuclear facilities. Over fifty facilities are being covered in the scope of this initiative. As of December 1, 1986, Technical Safety Appraisals of 10 facilities have been completed. By the end of FY 1987, 25 facilities will have been appraised, and follow-up will have been made on the findings of earlier completed appraisals. The same emphasis is proposed in FY 1988 with 17 more facilities scheduled.

The Computer Assisted Tracking System in its basic configuration became operational in late FY 1986 and is being used to track Technical Safety Appraisal recommendations and Environmental Survey findings and related corrective actions. System development is continuing in FY 1987 by adding modules for maintaining up-to-date information on compliance under the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA), accident investigations, and priority line item projects, to mention just a few.

Another initiative, added in January 1986, is establishment of a central Environmental Issues Coordination function within the Office of Environment, Safety and Health. This has also been implemented. This process was established to ensure a consistent and coordinated approach Department-wide with respect to environmental compliance issues. Through this process we have successfully negotiated and completed a number of Federal Facility Compliance Agreements with the States and EPA. These include agreements for the Fernald, Portsmouth, Hanford, Savannah River, Rocky Flats, Oak Ridge and Weldon Springs facilities.

Simultaneously with these formal initiatives, we have taken steps to upgrade the environment, safety and health policy and guidance functions. The Office now has specific offices designated to develop and coordinate environmental and safety policy and guidance development. The Department's Environment, Safety and Health Order system, which underwent substantial redevelopment in FY 1986 with publication of six revised safety Orders, is in a second phase of updating which will result in the publication of revised radiological protection Orders for worker and public safety, a general environmental policy Order, and special Orders for implementation of RCRA and SARA.

We are using every available mechanism to provide timely guidance on changing standards and requirements. In FY 1987, a Nuclear Safety Council and an Environmental Council were established to coordinate Departmental initiation and development of appropriate response to important policy issues. In addition, frequent high-level staff coordination meetings are being held with Headquarters and Operations Offices to discuss environment, safety and health issues; and we have established a much stronger presence for the Office in all levels of Departmental decisionmaking. For example, we have adopted a more active role in safety system reviews of facilities and the concurrence process for startups of facilities. Also, in FY 1986, new authorities were assigned to the Assistant Secretary concerning recommending or authorizing curtailment or suspension of operations. The Office has also institutionalized and improved its evaluation and setting of priorities for environment, safety and health projects. For FY 1988, my office evaluated and ranked 64 project proposals and advised the Secretary of our recommended priorities.

PLANNED FY 1987 PROGRAM ACCOMPLISHMENTS

During FY 1987, the Environment, Safety and Health program is emphasizing the same needs as in FY 1986, but with the application of greater resources. Top priority is being given to the Environment, Safety and Health initiatives to maintain them on track, and to bring the product of these efforts to bear on program operations. Efforts are being stepped up to keep pace with the increasing body of legislative and regulatory requirements applying to DOE facilities, most notably in the hazardous waste management area, and to issue timely guidance and policy to the Department's Field Organizations. Among the significant accomplishments we hope to achieve are:

- Complete the on-site Environmental Survey activities at 20 DOE sites; initiate and complete the sampling and analysis of 13 sites.

- Continue the nuclear safety appraisal program, including 17 Technical Safety Appraisals, 2 Nuclear Safety Program Appraisals, and follow-up to FY 1986 appraisals.

- Continue efforts to establish Federal Facility Compliance Agreements by completing agreements at 6-10 priority sites.

- Perform technical evaluations of safety analysis reports for new high-hazard and selected new moderate-hazard nuclear facilities.

- Provide environmental guidance and compliance assistance to the programs and field offices, and provide oversight of programs, projects, and operations subject to environmental requirements. Review and update radiological protection, SARA, RCRA and general environmental policy orders.

- Perform an estimated 140-160 reviews of NEPA documents and 180-200 NEPA-related analyses or guidance actions.

- Conduct fire protection surveys at 5 major sites.

- Review safety issues of several of the Department's major nuclear reactors and concur in the conduct of safety enhancements which would provide an early resolution of identified safety concerns.

- Improve capability to measure radiation exposure to DOE workers through improved dosimetry and instrumentation.

FY 1988 FUNDING

The FY 1988 budget request for the Environment, Safety and Health Program is $70.0 million, an increase of $8.0 million above the FY 1987 appropriation, as noted in the following table. The increase is primarily for 3 areas: (1) the development of the environmental audit program including all planning and preparatory work, procedures, and protocols; (2)

expansion of the level-of-effort on Technical Safety Appraisals and technical evaluations of safety analysis reports; and, (3) salaries and benefits for increased staffing levels and for the new Federal Employees Retirement System.

FUNDING SUMMARY
(Budget Authority in Millions)

Environment, Safety and Health

	FY 1987 Appropriation	FY 1988 Request	Changes From FY 1987
Environmental Audit....	$23.0	$26.0	$+3.0
Nuclear Safety.........	17.2	19.2	+2.0
Operational Safety, Quality Assurance, Environmental, Guidance, Compliance, and Analysis..............	10.4	10.7	+0.3
Program Direction......	9.3 1/	12.0	+2.7 1/
Capital Equipment......	2.1	2.1	--
Total...............	$62.0	$70.0	+8.0
Staffing (FTEs)	152 2/	162 2/	+10

1/ Total estimated funding requirement for FY 1987 is $10.6 million. Difference to be absorbed by unobligated carryover funds. Actual increase from FY 1987 to FY 1988 is $1.4 million.

2/ Does not include 3 FTEs budgeted under the Nuclear Waste Fund.

FY 1988 PROGRAM OVERVIEW

Environmental Audit: The Environmental Audit function comprises the baseline Environmental Survey and the follow-on environmental audit activity. In FY 1988, on-site Survey work will be completed at sixteen additional sites, concluding the final total of forty-one sites to be covered in the Survey. Sampling and analysis activity, which follows the on-site Survey activity, will be completed at nineteen additional sites leaving 7 sites to be sampled in FY 1989. Work on preliminary site reports continues leading to preparation of a final report of the entire Survey in FY 1989. An increase of $3 million is requested in FY 1988 to initiate and complete necessary planning and preparatory work for the environmental audit activity. The role of the audit program will be to assess, on an ongoing basis, the status of environmental programs and conditions at each site and to determine the effectiveness of those programs. Actual audit performance will begin in FY 1989.

Environmental Guidance and Compliance: The Environmental Guidance and Compliance function provides environmental policy and guidance to the Field Organizations with respect to implementation of applicable requirements, and provides oversight and coordination of compliance activities, including Federal Facility Compliance Agreements. This function also provides technical assistance to the field organizations on compliance matters. An increase of $300,000 is requested in FY 1988, to continue baseline efforts to develop badly needed implementation guidance under hazardous and mixed waste policy rules, and to draft orders pertinent to implementation of RCRA and SARA.

NEPA Project Assistance: The NEPA Project Assistance activity performs a variety of National Environmental Policy Act assurance functions including project review, technical assistance, document review and establishment of NEPA compliance policy. In FY 1988 funding remains at prior year levels, sufficient to sustain the baseline program to assure Departmental compliance with the National Environmental Policy Act.

Environmental Analysis: The Environmental Analysis activity accomplishes analyses and coordination of environmental issues that have a potential impact on U.S. energy systems. It is the national environmental policy function with respect to energy issues for the Department. Air quality and waste disposal issues will dominate the environmental analysis agenda in FY 1988. Primary effort in FY 1988 is directed to analysis of reports in support of the National Acid Precipitation Assessment Program (NAPAP) and to related studies to support the Department's acid rain policy position. No increase is proposed for this program function in FY 1988.

Nuclear Safety: The Nuclear Safety activity is a wide-ranging function that comprises oversight of nuclear facility safety, technical assistance, training assistance, radiological protection and emergency preparedness. Top priority in this activity is the continuation of the Technical Safety Appraisal program. An additional 17 facilities will be appraised in the program in FY 1988 making a total of forty-two since the program's inception. The initial review of major nuclear facilities will be completed in FY 1989. A priority being given substantially increased attention in FY 1988 is safety analysis review of new and existing nuclear facilities. A $2 million increase is requested for the Nuclear Safety program for the above priorities and for maintaining and upgrading the Atmospheric Release Advisory Capability System.

Quality Assurance: The Quality Assurance program is an oversight function that assures that DOE systems and facilities are designed, constructed, managed and operated according to sound technical and quality assurance standards. Emphasis in this program area continues to be given to the quality assurance audit and appraisal activity and the implementation of the Unusual Occurrence Reporting System including data analysis and maintenance of a Department-wide data base. No increase is given this program activity in FY 1988.

Operational Safety: The Operational Safety program provides occupational safety and health oversight of all Department-owned, contractor operated facilities to assure that employees and property are protected against safety and health hazards. The function comprises a wide scope including occupational medicine, industrial hygiene, aviation safety, fire protection, safeguards and explosive safety, hazardous materials packaging and transportation, non-nuclear facility safety and the Safety Performance Measurement System. No increase is given this function in FY 1988. The baseline program will continue to focus on appraisals, safety training support and technical assistance on specific issues.

Safety Policy: The Safety Policy office assures proper coordination and a consistent approach in the development and implementation of the Department's safety policy. The work of this office emphasizes assurance of comparability between the Department's safety policy and standards and those of other regulatory bodies such as the Nuclear Regulatory Commission. This is an internal staff function for which no outlays are projected in the budget through FY 1988.

Program Direction: This line-item covers staff and certain other services including support to the Computer Assisted Tracking System. The FY 1988 staffing request is for 162 FTEs, an increase of 10 FTEs over FY 1987. An increase of $2.7 million provides for additional personnel support costs including pay cost supplemental and retirement system increases. The Computer Assisted Tracking System is maintained as a baseline effort.

Capital Equipment: Capital Equipment outlays remain at the FY 1987 level of $2.1 million. Outdated equipment needed for the emergency preparedness system will be replaced. Additional computer storage and processing equipment will be purchased for the Computer Assisted Tracking System, and laboratory equipment will be purchased to support health physics testing and analysis.

I appreciate the support of the Subcommittee for the Department's Environment, Safety and Health Program and would be pleased to respond to your questions.

BIOGRAPHICAL SKETCH

MARY L. WALKER

Mary L. Walker was nominated by the President for the position of Assistant Secretary for Environment, Safety and Health, U. S. Department of Energy (DOE), on September 23, 1985, and confirmed by the Senate in December 1985. In this position, she manages the Department's environmental and safety guidance, compliance and oversight functions. Her responsibilities include oversight of over 260 nuclear facilities and 160 non-nuclear facilities. She also develops the Department's environmental and safety policies and standards and assists the Department's field operations and programs in the areas of new project review, liaison with states and federal agencies, technical expertise and compliance.

From June until December, 1985, Ms. Walker was a special consultant to the Secretary of Energy. Previously, she served as the Deputy Solicitor for the Department of the Interior under William Clark. In this role, she supervised 220 attorneys including eight Regional offices, and provided legal counsel to the Secretary and program heads on the many varied legal issues involving that Department.

In 1982 she was recruited by the Reagan Administration as the chief Deputy Assistant Attorney General in the Land and Natural Resources Division, U.S. Department of Justice. She supervised a staff of 155 persons and managed the federal government's environmental litigation, involving over 2,500 cases relating to the federal government's protection and regulation of land and natural resources.

Ms. Walker was a partner with the Los Angeles law firm of Richards, Watson & Gershon, practicing in the areas of land use and environmental law and litigation from 1976-1982. In addition to representing individual and corporate clients, Ms. Walker represented various public entities, including approximately twelve Southern California cities. She handled matters involving federal and state agencies, and is experienced in both federal and state court litigation.

From 1973-1976, Ms. Walker was an attorney with Southern Pacific Transportation Company in San Francisco. She represented Southern Pacific and its diverse subsidiaries, including railroad, pipeline, trucking and land companies, in the then-emerging area of environmental law.

Ms. Walker received her B.A. in biological sciences/ecology from the University of California at Berkeley in 1970. She attended U.C.L.A. Law School and Boston University Law School, receiving her J.D. in 1973.

September 1986

PRICE-ANDERSON ACT

Senator JOHNSTON. Thank you, Ms. Walker.

We had a hearing this morning on the Price-Anderson Act. There was a deep difference of opinion on the question of whether contractors at DOE nuclear plants should be liable for gross, wanton, willful negligence.

There were those who said that without that penalty of being liable for that, they would not be sufficiently careful.

There were others who said that if they were subjected to that, they would not be able to get insured, there would be fewer, and, in fact, you might not really get the big contractors in, they may just simply be frozen out of the market.

Some 78,000 suppliers of materials, perhaps, would be unwilling to supply materials because it wasn't that profitable, the nuclear part was only a small part of their business, to subject themselves to that huge liability.

Do you have a view on that?

Ms. WALKER. First of all, I have to indicate that this is not my area of the Department, and I wouldn't want to speak for the nuclear industry as to what the problems might be should the terms of the Price-Anderson Act be changed such that they would have a greater exposure to liability that may result in great difficulties. The controversy surrounding the nuclear area has not subsided, and certainly with Chernobyl the fears are such that those may be very real concerns.

I really feel, in terms of the Department, I would like to furnish you the official position for the record, this might be most appropriate.

[The information follows:]

PRICE-ANDERSON ACT

The Department's position on extending and amending the Price-Anderson Act was stated most recently by Assistant Secretary for Nuclear Energy, Dr. A. David Rossin. I would like to submit that statement for the record.

[The information follows:]

STATEMENT OF DR. A. DAVID ROSSIN, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY

Mr. Chairman, it is a pleasure to be here today to discuss extending and amending the Price-Anderson Act.

The Price-Anderson Act is a forward-looking mechanism designed to assure the American public that their claims for injury will be promptly addressed and paid in the event of a major nuclear incident. Price-Anderson is a key factor in assuring the continued participation of the private sector in Department of Energy (DOE) nuclear programs and activities as well as ensuring the continued viability of this Nation's commercial nuclear power operations. The Department strongly supports a reasonable extension of the Act.

IMPORTANCE OF PRICE-ANDERSON TO DOE OPERATIONS

The unique umbrella protection provided by Price-Anderson continues to be invaluable in the conduct of the Federal Government's nuclear activities. The Department is highly dependent on products and services offered by various businesses, professional organizations, educational institutions, and other entities. Without continuation of the Price-Anderson Act, contractors at all levels may well refuse to continue doing business with the Department, including those organizations with which the Department contracts to manage major Government-owned installations.

Price-Anderson balances the limited liability of DOE contractors (or nuclear plant operators for licensed facilities) against certain, rapid, and widely available compensation to the public who may be injured in the unlikely event of a major nuclear incident. The term "limitation on liability" is frequently misunderstood in that it does not represent an absolute limitation on either liability or claims that may be paid as a result of a nuclear incident. Rather, exceeding the statutory threshold would trigger Congressional review of the incident to determine how best to proceed, based on the facts and circumstances of the accident. Congress has wisely and appropriately reserved to itself a final review of any incident which exceeds the statutory threshold in order to determine actions that may be required to further protect the public against the consequences of a catastrophic nuclear incident.

In addition, Price-Anderson "channels" financial protection coverage through the prime DOE contractor to subcontractors, suppliers, and vendors who sell, design, build, test, or perform other work or services on any component of a nuclear facility or device. The Department has no other means of indemnifying contractors that would provide this unique mechanism for protecting its contractors and their subcontractors from liability claims, while providing potential claimants a mechanism for prompt and assured payment of claims.

THE NEED TO CONTINUE PRICE-ANDERSON

On August 1, 1987, Price-Anderson authority to indemnify DOE contractors and cover new nuclear facilities licensed by the Nuclear Regulatory Commission (NRC) will expire. This will have little effect on existing NRC-licensed reactors, which are covered under Price-Anderson for the life of the reactor. However, DOE will not be authorized after August 1 to indemnify its contractors under Price-Anderson in new or renewed contracts unless Congress acts now to extend this important provision of the Atomic Energy Act.

Of equal importance, a future without some Price-Anderson type of coverage would inhibit our collective ability to revitalize the nuclear power option in the near-term. The forward-looking structure and framework of the Price-Anderson nuclear insurance and indemnification system established by Congress in 1957 remains equally important today in assuring that new nuclear powerplants can contribute to meeting our future electricity needs.

KEY LEGISLATIVE PROVISIONS

In 1983, DOE and the NRC each submitted their recommendations for extending the Price-Anderson Act. The subject has been debated extensively over the past 2 years, and we have testified 7 times during that period on various legislative proposals, including those introduced during the 99th Congress. DOE continues to support the views expressed in our prior testimony and is prepared to support compromise legislation that would extend the Act. The key elements of an acceptable framework would provide for:

- liability limits for "traditional" nuclear activities (involving DOE contractor and NRC-licensed nuclear operations) as well as for high-level and transuranic radioactive waste disposal activities;
- comparable liability limits for DOE contractors and NRC licensees;
- retention of a congressional review process to determine not only the source of additional funds, if claims would ever exceed the initial limitation on liability, but also to determine the method for providing full compensation for valid claims of the victims of a nuclear incident;
- extending the waiver of defenses provision for an extraordinary nuclear occurrence that would expressly provide coverage for high-level and transuranic radioactive waste disposal activities;
- payment of claims arising out of activities conducted under the Nuclear Waste Policy Act from the Nuclear Waste Fund;
- payment of costs incurred in investigating, settling, or defending damage claims under Price-Anderson from insurance proceeds, deferred premiums, or government indemnity funds provided under Price-Anderson; and,
- retaining a reasonable statute of limitations--no more than 30 years, with a 3-year discovery period for injury.

Additionally, Price-Anderson legislation must not include any provision that could abrogate the sovereign immunity provisions of the Federal Tort Claims Act and inappropriately permit the Government to be sued for its actions as if it were a contractor.

DOE COMMENTS ON S. 843

DOE is particularly concerned that S. 843, currently under consideration by this subcommittee, would destroy the congressional review process available under current law. Although S. 843 provides an initial limitation on liability for DOE contractors (and NRC licensees) of approximately $7 billion, based on the current number of licensed commercial reactors, Congress would be able to assess additional payments from any "persons," including those who have already made payments, to fully compensate the public in the unlikely event of a major nuclear accident.

The Department continues to strongly oppose unlimited liability for both DOE contractors and NRC licensees. The Price-Anderson system has "worked" for nearly 30 years because Congress has carefully balanced the public's desire for prompt financial protection against a nuclear incident and both the Federal Government's and the nuclear industry's concern for a "limit" on its liability. While other proposals currently under consideration in both the House (H.R. 1414) and Senate (S. 748, limited to DOE contractors) would substantially modify Price-Anderson, neither bill would destroy this essential "balance."

S. 843 would modify the congressional review process so significantly that the balance in existing law would be destroyed. S. 843 could be interpreted to provide that, if damages exceed the initial limitation on liability, Congress could decide only how to fund the liability. Courts could interpret S. 843 to permit them to continue to award damages, after the initial limitation on liability has been exceeded, under normal tort law--with a waiver of defenses in the event of an extraordinary nuclear occurrence. The result of such an interpretation could be to prevent Congress from determining whether a streamlined compensation system should be established that would preserve tax dollars for the payment of claims, rather than the payment of attorney fees and court costs. Under current law, Congress can establish an administrative system to eliminate these costs and ensure that claims could be paid on an even more expedited basis than permitted under the waiver of defenses provisions. S. 843 could be interpreted to eliminate this option currently available to Congress.

DOE COMMENTS ON S. 44

Enactment of S. 44 would also destroy the carefully crafted balance that is the hallmark of the current Price-Anderson system. S. 44 would provide for unlimited liability for both NRC licensees and DOE contractors engaged in waste-related activities. In addition to providing for unlimited liability, this proposal could abrogate the sovereign immunity provisions of the Federal Tort Claims Act and inappropriately permit the Federal Government to be sued for its actions as if it were a contractor. The Department strongly opposes both provisions.

DOE COMMENTS ON AMENDMENT 3238 TO S. 1225

Amendment 3238 was introduced in the Senate during the final days of the 99th Congress as a substitute for the two versions of S. 1225 that had been separately reported to the full Senate by the Committee on Energy and Natural Resources and the Committee on Environment and Public Works. This was an attempt to reconcile the two versions of Price-Anderson legislation so that, if time permitted, the amendment could be called up on the Senate floor for consideration. With the introduction of H.R. 5650, similar efforts were underway at roughly the same time in the House. Unfortunately, floor action did not take place in either chamber.

S. 1225, as amended by Amendment 3238, preserves the essential balance between the needs of the public, the Federal Government, and industry. However, the amendment includes a provision that would treat the Secretary of Energy as if he were a contractor in the event that certain nuclear waste activities were not undertaken by contract. Of the three bills being considered today, the Department considers that this proposed bill comes closest to meeting our objectives as cited above; however, the Department strongly opposes any provision, including the one in this proposal, that could be interpreted as a waiver of sovereign immunity.

CONCLUSION

It is important that we proceed quickly to complete legislation on a reasonable extension of the Price-Anderson Act as early as practical in this session of Congress. The certainty of continued coverage under this unique legislation is important for both the Department and its contractors. Little time is left before the August 1, 1987, expiration date to remove the uncertainty that exists in firming up contractual arrangements for activities beyond that date.

We recognize that there are differing views on liability limitations, treatment of waste activities, and other provisions of the Act that have been debated in the past 2 years. However, the time has passed for debate and the time is at hand for action to provide a continuing system of indemnification and liability protection that balances the needs of contractors and nuclear facility operators with assured protection of the public.

The Department stands ready to support this effort. We hope our testimony and comments today, plus any further assistance or information we can provide regarding specific features of proposed legislation, will enable you to favorably report needed and acceptable legislation to the Senate in the near future.

Mr. Chairman, this completes my statement. My colleagues and I are ready to respond to your questions at this time.

Senator JOHNSTON. You don't oversee safety in the nuclear plants?

Ms. WALKER. I do oversee safety for the nuclear plants for the Department of Energy's production facilities, our own energy research and production reactors. I do not have oversight over the commercial sector, and that sort of thing, in other words, the nuclear industry, the commercial and private sector industry.

The Price-Anderson Act, basically, is followed through our congressional office and the Office of Nuclear Energy, which is headed by Assistant Secretary Dave Rossin. My Office occasionally participates in certain areas of expertise, and we do get involved. I would like to supply you with the official position, for the record, on that statute.

Senator JOHNSTON. What is your observation of nuclear contractors in those facilities that you oversee?

Ms. WALKER. In terms of the Department's provisions with its contractors in terms of environmental aspects, especially with respect to fines and penalties, and that sort of thing, we have in our contracts a provision whereby we indemnify the contractors for fines and penalties incurred in the performance of their duties, except if they are incurred as a result of bad faith or willful misconduct.

In other words, if they intentionally disobey an environmental law, and there are consequences and they are fined, then we might not and would not indemnify them, if that were the case. But where in the course of performing their duties, an environmental accident or something, for example, a spill occurs and they are fined as a result of that, we do indemnify them.

My own feeling is that environmental and safety excellence is the result of personal commitment to that by line management, and a strong centralized oversight to assure that even with good practices and good performance, they do not become complacent. It has been the commitment of our Department, and I really think that this is what it will take in the end.

I don't know that specific legislation, and the terms of it being changed, I don't know that that will increase that commitment to excellence. I think that this is something you have to pursue and oversee to ensure that it is indeed the case.

GAO REPORT ON DOE FACILITIES

Senator JOHNSTON. The GAO has recently written me expressing a deep concern over environment, safety, and health aspects at DOE's facilities. They have recommended to the Secretary of Energy the development of an overall strategic plan addressing these issues and problems, including a comprehensive picture of the environment, safety, and health issues facing DOE, including the development of a ground water and soil protection plan. Actions are needed to ensure that these facilities are operated in a safe manner, and solutions to resolve these issues, along with associated costs and timeframes.

Are you familiar with that letter from GAO?

Ms. WALKER. Yes; I am.

Senator JOHNSTON. Has DOE formulated a response?

Ms. WALKER. We have not provided a formal response and that is being coordinated within the Department. However, what I can tell you is that Secretary Herrington, in my view, got there first, especially with respect to the environmental and safety recommendations.

GAO has some good points, and we have certainly concurred with their recommendation for a ground water strategy in the past. But in our concurrence, we explicitly stated that the Environmental Surveys and the Technical Safety Appraisals were designed to be the information base and the baseline data that would enable us to prepare such a strategic plan.

The first thing you have to know, as I said before, before you clean out the closet, you have to open the door and see what is there. What the Secretary wanted was a catalog of current problems and situations and areas of risk, so that he could understand, and so that we could correct the areas in their order of priority.

We have even developed, as a result of this, a prioritization system that EPA likes so much that they are thinking about using it themselves.

It really makes sense to go about strategic planning in that way, and that is what we have done. We think that we have put something in place to do that.

Certainly on the defense production side, the strategic planning for our facilities, some of which are aging, some of which are new, recognizing that we have a complex out there, while that is not my function, I am aware of the fact that the defense programs do have such a strategic planning effort ongoing.

It is my assumption that when we do reply to this, it will certainly be an agreement that such planning is in order, an explanation of efforts to date, and some projection of where they are going.

Senator JOHNSTON. You basically agree with GAO's conclusion and their statement of the problem?

Ms. WALKER. I don't have that statement in front of me, and I don't know, without having been through the complete review process yet, whether I would agree with everything in their description of the problem. I do think that there is a need for such strategic planning and I have indicated that we have already begun those efforts. We think that we are well on the way to enable the Department to perform that function.

I guess we would agree that it is important, both from an environmental and safety, as well as overall facilities perspective, and I am speaking for Admiral Foley, in terms of his area, that that kind of strategic planning does make sense, and is ongoing, or the foundations for it are being laid by the Department even as we speak.

HUMAN GENOME RESEARCH

Senator JOHNSTON. Dr. Trivelpiece, say a word about the human genome project and where that leaves us. We are very interested in that.

Dr. TRIVELPIECE. You are also interested in how much it will cost.

Senator JOHNSTON. By the way, I want to do all these things.

Dr. TRIVELPIECE. I had brought along some pamphlets here today, and I was going to submit them for you and the staff to look at to see whether or not you wanted to include them in the record.

[The information follows:]

HEALTH & ENVIRONMENTAL RESEARCH

Summary of Accomplishments

Prepared by

U.S. Department of Energy
Office of Energy Research
Office of Program Analysis

AUGUST 1986

This report is a companion document to *Health and Environmental Research: Summary of Accomplishments*, DOE/ER-0194, published in May 1983. The information for both reports was gathered in 1982 and 1983. These reports are intended to foster an awareness of a publicly funded health and environmental research program chartered nearly 40 years ago, of its contributions toward the National goal of safe and environmentally acceptable energy development, and of applications of its findings toward the improvement of human health. This program, administered by the Office of Health and Environmental Research, is one of many research activities of the U.S. Department of Energy. Over the years, it has been a part of other Federal agencies responsible for the National energy mission. Its evolution has been a reflection of changes in time, public priorities, and public law. But throughout, there has remained a consistency of purpose: to seek a fundamental understanding of the health and environmental aspects of emerging energy technologies and to establish the body of knowledge necessary to their development and utilization consistent with the public health and safety.

The story of this research program can be told through its accomplishments. Several of the more significant accomplishments have been chosen here for illustrative purposes, including some whose value have far exceeded the cost of the research program itself. However, regardless of the measure of its economic benefit, the basic motivation for the program remains to *serve the public interest* through health and environmental research. In the pages that follow, the selected accomplishments are grouped and reviewed within each of several areas of research. It is useful, first, to recall the origins and development of the program.

Executive Summary

This is an account of some of the accomplishments of a 40-year-old health and environmental research program performed in National Laboratories, universities, and research institutes. Under the sponsorship of the Federal agencies that were consecutively responsible for the National energy mission, this research program has contributed to the understanding of the human health and environmental effects of emerging energy technologies.

Both direct and indirect societal benefits emerged from the new knowledge provided by the health and environmental research program. In many cases, the private sector took this knowledge and applied it well beyond the mission of supporting the defense and energy needs of the Nation. Industrial and medical applications, for example, have in several instances provided annual savings to society of $100 million or more. Collectively, the diffusion of this knowledge has resulted in annual savings to the Government and to the public that are several times larger than the cumulative cost of the entire program itself.

The form of this presentation is, in fact, through "snapshots"—examples of significant, tangible accomplishments in each of the areas at certain times to illustrate the role and impact of the research program. The program's worth is not necessarily confined to such accomplishments; it extends, rather, to its ability to identify and help solve potential health and environmental problems before they become critical. This anticipatory mission has been pursued with an approach that combines applied problem solving with a commitment to fundamental research that is long-term and high-risk.

The narrative of this research program concludes with a perspective of its past and a prospectus on its future.

Origins of the Research Program

The origins of the Office of Health and Environmental Research (OHER) trace back to the outset of World War II and the establishment of nuclear research centers under the "Manhattan Project." The first formal program began in 1942 as a Health Division, established by Dr. Arthur Holly Compton, Director of the University of Chicago Metallurgical Laboratory. Already a Nobel laureate for his work on X-ray scattering, Dr. Compton recognized the unprecedented hazards posed by radiation to wartime workers at the laboratory. With the perspective of a half-century of earlier experience with X-rays and radium, he and his colleagues could well appreciate the dangers, as well as the possibilities, of atomic radiation. Biomedical programs were soon established at Oak Ridge, Tennessee, and in the Manhattan Project at large, and it is fortunate that these were able to attract the most competent physicians and medical researchers in the field of the biomedical effects of radiation.

Like the Curies and other pioneers in the field of radiation, those who sought to protect the health of their colleagues could understand, more than others, that the phenomenon that so concerned them was, at the same time, an opportunity. They grasped its significance and foresaw the promise of radiation and nuclear medicine as a new means for medical diagnosis and treatment. This promise has been fulfilled. Today, radiopharmaceuticals are produced and packaged in myriad forms and are in widespread use; for example, radiopharmaceuticals containing thallium-201 ions were administered for the diagnosis of heart disease to 370,000 patients in 1981.

In providing the first legislative basis for the health research program through the Atomic Energy Act of 1946, the Congress overlooked neither the opportunities nor the dangers presented by radiation. In the Act the Congress directed the Atomic Energy Commission (AEC) to

> ***. . . make contracts, agreements, arrangements, grants-in-aid, and loans . . . for the utilization of fissionable and radioactive materials for medicine and health purposes . . .***

and for

> ***. . . the protection of health during research and production activities . . .***

The need for a highly qualified group of research administrators was foreseen to fulfill this broad charter. Thus, the Division of Biology and Medicine was established, and Dr. Shields Warren, Professor of Pathology at Harvard University, was named its first Director. Under Dr. Warren, the Division laid down the outlines of a vigorous research effort of fundamental studies in the life sciences; in applied areas to ensure industrial hygiene in Commission facilities, as well as for the public health and safety; and in fostering the rapid growth of nuclear medicine.

The responsibility for administering this program was assigned to the Energy Research and Development Administration (ERDA), which succeeded the AEC through the Energy Reorganization Act of 1974. However, the oil embargo had underscored the need for developing a wide range of energy options and technologies in addition to nuclear, and this need was reflected in the new agency's mission. Therefore, this Act additionally charged the ERDA Administrator with the responsibility of

> ***. . . engaging in and supporting environmental, physical, and safety research related to the development of energy sources and utilization technologies.***

These responsibilities were assumed by the Agency's Division of Biomedical and Environmental Research, which initiated a significant program of non-nuclear research, focusing on the development of fossil fuels and renewable energy sources. At the same time, a broad range of legislation* strengthened and expanded the rationale for ERDA's program of health and environmental research by establishing a regulatory framework by which the results of this research could be integrated directly into the planning and development of energy technologies.

Although ERDA was relatively short-lived, these research functions were retained intact by the new Department of Energy (DOE), established in 1977. Within the Department today, these responsibilities have been carried on by OHER.

What, then, has been the net result of OHER's history of changing roles and mandates? A central mission has evolved, requiring the integration of three fundamental areas of study: (1) the "source," or potentially toxic agent of concern; (2) its "transport," or path from its point of release; and (3) the "effects" that it may produce upon populations and the environment.

The first of these areas of study involves the understanding and characterization of the material, pollutant, or agent of concern. Despite the seemingly limited scope of this phase of study, it can lead to unexpected rewards of a much broader nature. For example, the OHER mandate under the Atomic Energy Act required an understanding of radiations of various kinds and their interactions. This, in turn, created a need for the development of a host of radiation detection instruments, some of which became essential to the field of nuclear medicine, as noted later.

The second facet of the mission—source transport—began as an effort to understand the paths that might be taken by radioactive materials through the environment. But, as the range of energy options under development increased, the transport of materials from other technologies—coal fly ash, combustion gases, synthetic fuel components—also came under study.

The final segment of OHER's integrated mission is to detect the nature and extent of any possible danger to man and his environment from the potentially toxic source materials. Once again, initial research in this area was confined to radiation biology, the study of mechanisms and magnitudes of effects produced by radiation. These studies included the uptake and distribution of radioactive materials in animals and man to determine potential toxicity. This knowledge, when coupled with developments in nuclear instrumentation, provided the basis for the parallel development of nuclear medicine. The latter was but one of the new directions in research to receive its impetus from radiation biology. The quest for answers to the mysterious response of cellular deoxyribonucleic acid (DNA) to radiation spawned an unparalleled research program in basic genetics.

Thus, the objective of the OHER mission has been straightforward—to perform fundamental research on the energy-related triad of *source-transport-effect* and to integrate its basic findings toward the solution of practical questions.

The OHER Program employs a multidisciplinary "team" of nearly 1000 scientists in specialized facilities that have come to be

Table 1. Health and Environmental Research Laboratories

1. Multiprogram Laboratories
    - Argonne National Laboratory (ANL)
    - Brookhaven National Laboratory (BNL)
    - Lawrence Berkeley Laboratory (LBL)
    - Lawrence Livermore National Laboratory (LLNL)
    - Los Alamos National Laboratory (Los Alamos)
    - Oak Ridge National Laboratory (ORNL)
    - Pacific Northwest Laboratory (PNL)
    - Savannah River Laboratory
2. OHER-Dedicated Laboratories
    - Environmental Measurements Laboratory
    - Inhalation Toxicology Research Institute
    - Oak Ridge Associated Universities
    - University of California, Davis Laboratory for Energy-Related Health Research
    - University of California, Los Angeles Laboratory of Biomedical and Environmental Sciences
    - University of California, San Francisco Laboratory of Radiobiology and Environmental Health
    - University of Georgia, Savannah River Ecology Laboratory
    - University of Rochester Biomedical Laboratory
    - University of Utah Radiobiology Laboratory

regarded as National resources for biomedical and environmental research. (Table 1). For example, in FY 1985 other Federal, State, and local agencies, and private industry invested over $115 million in DOE laboratories to conduct health and environmental research to help address their own mission needs. Additional research supported by the OHER Program is conducted at some 100 academic campuses, hospitals, and other research institutions. Hundreds of OHER-funded scientists hold academic appointments and serve as important resources in the formal education of the Nation's scientists, engineers, and physicians. Many of the research projects supported at the laboratories also serve as vehicles for training predoctoral students, as well as postdoctoral investigators. In addition, opportunities are provided for research collaboration with visiting scientists who stay for extended periods of time.

Throughout its history OHER's philosophy has been to encourage prompt dissemination of research results at scientific meetings and in the scientific literature. Scientists currently supported by the program make nearly 2000 presentations each year at technical meetings and document their work in more than 2000 journal articles that have been peer-reviewed prior to publication.

In addition to the intellectual and scientific resources which have made these advances in knowledge and technologies possible, the National Laboratories possess multiuser facilities that are having a major impact on the rate of progress in elucidating the structure of biological molecules. Such structural determinations are a prerequisite for solving molecular design problems; for example, the modification of proteins so that they have a specified type of activity. Moreover, the unparalleled computational resources available at the laboratories and the broad capability to exploit them fully also provide the environment necessary for major advances in predicting small molecule structure and activity, which are central to identifying mutagens and carcinogens and designing drugs and vaccines. Together, these structural biology activities will provide the firm foundation crucial to maintaining America's competitive advantage in private sector biotechnology during the coming decades.

The funding for the Biological and Environmental Research Program is shown in Table 2, which also defines extensively the organizational structure of OHER. As in any large-scale research program, activities being conducted vary from year to year as existing projects are completed and new projects or lines of investigation open up. A synopsis of the principal research activities currently under way is presented in the Appendix.

The following descriptions of program accomplishments provide a glimpse of some of the more tangible products of the OHER research process. Having provided the background for the presentation of these products, some caveats are in order.

As in any other research enterprise, there is a continuum of effort, and a "snapshot" of selected OHER Program accomplishments can easily create a distorted view of the overall workings of the program. It has already been noted that while many of the accomplishments described have proved to be of considerable economic importance, that is not necessarily a measure of the effectiveness of the research within the context of the OHER mission, nor is it a factor in shaping its research agenda. The course of research is complex and can lead to a number of "dead ends," as well as to successes and breakthroughs. A seemingly fruitless effort can sometimes be useful by virtue of its indication of more productive pathways, and one of the accomplishments described, which eventually ended in a treatment for Parkinson's disease, provides a case in point. Basic research, a key part of the program, is long-term and often not immediately and measurably beneficial. Yet even in the event of no immediate product, the insights gained into the operation of biological processes improve our capability to anticipate or predict how the system will respond to new or untested events for which data are sparse or unavailable. The bone-marrow transplantation work undertaken early in the program is an example of basic research that ultimately provided much of the information that supports the current state-of-the-art for organ transplantation work in medicine.

Thus, in summarizing the accomplishments of a research program designed for a mission as far-reaching as that of OHER, its

Table 2. Funding for Biological and Environmental Research
(Dollars in Millions)

Research	Appropriations	
	FY 1984	FY 1985
Human health research to quantify risks of late effects of acute and chronic exposures via epidemiological studies of workers and the general population and to develop methods to detect and measure latent disease induction or identify highly susceptible individuals	25.6	24.8
Health effects research in biological systems to define experimentally dose-response relationships and the factors influencing carcinogenic, mutagenic, and toxicological risks of energy-related exposures; and basic biological research to elucidate the mechanisms by which physical and chemical agents may cause their effects	57.0	59.5
Environmental research to determine the mechanisms that control and influence total ecosystems and the cyling of energy by-products through them	23.8	21.3
Physical and technological research to characterize energy-related emissions to which humans may be exposed and improve measurement and dosimetry instrumentation	27.6	35.4
Health and environmental risk analysis of emerging energy technologies	1.8	0.0
Nuclear medicine: research to develop new radioisotopes, labeled compounds, clinical procedures, and visualization devices for improved diagnosis, treatment, and study of human diseases	20.8	21.8
CO_2[*]	12.4	13.3
Program direction	3.3	3.5
Total operating	173.3	179.6
Capital equipment and construction	10.7	10.9
Total	184.0	190.5

[*] CO_2 research is managed by the Basic Energy Sciences Program staff but is budgeted under the Biological and Environmental Research Program. CO_2 research is not discussed in this report.

worth should not be judged solely on the basis of economic benefit or immediate applicability. The result of research may be a tangible product (e.g., a nuclear scanner or radiopharmaceutical) of readily calculable value. But the "product" may also be the answer to the riddle of self-repair to cell injury, the mechanism by which a particle is transported, or the definition of the risk of bone cancer from radiostrontium. Thus, it is equally valid to judge the benefit of a research contribution in terms of its reduction of uncertainty or its description of a previously unknown mechanism. These criteria have been in consonance with the energy development missions of OHER's parent agencies (AEC, ERDA, and DOE), which, in an anticipatory manner, have made use of its research to prevent, modify, or mitigate potential health and environmental effects before an emerging technology reaches maturity. The contrast between the anticipatory nature of OHER research and that which is conducted by the regulatory agencies is readily apparent from the differing content and objectives of their respective research programs. The ultimate goal of the research program is, therefore, not so much to find effects as it is to aid in their prevention. The extent to which that goal is realized is the true measure of its benefit to the Nation.

The following sections contain descriptions of selected, definitive research contributions resulting from the program—accomplishments of the many individuals in National Laboratories, universities, and research institutes who conduct this work under contract to OHER. In some instances the research has been cofunded or is now pursued under auspices other than OHER.

Emerging Energy Technologies

OBJECTIVE: Through Research, Examine the Potential for Adverse Effects on Human Health and the Environment from Emerging Energy Technologies.

It is the purpose of this Act... to advance the goals of restoring, protecting, and enhancing environmental quality and assuring public health and safety,...

—Sec. 102, Public Law 95-91

The functions which the Secretary shall assign...shall include...conducting a comprehensive program of research and development on the environmental effects of energy technologies and programs....

—Sec. 203, Public Law 95-91

This new organization act identified, for the Department of Energy (DOE), responsibilities for public health and safety that were virtually identical to those of the AEC in its nuclear development and production programs and ERDA in its development of energy conservation and both nuclear and non-nuclear energy-supply technologies. In all three charters the intent of Congress was clear: to foster a better understanding of the potentially adverse effects on human health and the environment of emerging energy technologies. The dramatic dislocations following the oil embargoes of 1973 and 1979 gave impetus to the development of the emerging technologies—synthetic and renewable, as well as nuclear, fuels—and, thus, added to the urgency of these responsibilities.

Identification of Human Health Effects

Early in the OHER Program, concerns centered around the responses of humans and animals exposed to radiation. Specific experiments to measure radiation effects were initiated and led very quickly to the realization that to recognize damage, scientists first had to understand the structure and functioning of healthy cells, tissues, animals, and, ultimately, humans. The resulting research program would make, and continues to make, major contributions to biology, medical diagnosis and treatment, ecological science, genetics, biophysics, immunology, DNA repair, and the study of the causes of cancer, to mention only a few of the affected and enriched scientific areas.

The next decades could see a rising potential for new pollutants from such technologies as oil shale and synthetic oil from coal or from diesel emissions. The movement of these pollutants through the air, land, and water and possibly back to human beings would have to be evaluated. It is important to understand the ability of the environment to break down, detoxify, and absorb the residuals from these new chemicals. Testing their ability to cause cancer, mutagenic effects, or somatic damage is also needed to help minimize health and environmental effects. The time when guidance can be most helpful and least expensive is before billions of dollars are invested in new energy technologies.

Finally, should the unexpected occur, the OHER has developed capabilities to respond to emergency situations and realistically assess the potential public health hazards of toxic releases to the atmosphere. These systems were originally designed to predict fallout from atmospheric nuclear weapons testing but have evolved into an especially effective atmospheric-dispersion forecasting for chemical releases as well.

Nuclear Technology The biological and medical research program initiated during the World War II "Manhattan Project" has sponsored extensive research studies and measurements to determine the mechanisms and extent of radiation effects on human health through direct studies on exposed human populations and by experiments on animals, tissues, cells, and individual molecules of interest. Data on the health impacts of different types and levels of radiation exposure, the interaction of radiation with living tissue, and the manner in which radioisotopes are taken up into the body have been evaluated and used to determine the risks posed by radiation to industrial workers and the general public. Such risk analyses have been used in the development of industrial hygiene practices, radiation exposure control guidelines, and regulatory criteria for the location, design, and operation of nuclear facilities. From the collective effort, a new scientific discipline, radiation biology, emerged and revolutionized the study of biological, ecological, and medical systems. Radiation biology has increased our understanding of fundamental processes by enabling greater quantification of results through new instruments and techniques and by applying the multidisciplinary skills of physical and biological scientists to vital questions of health, illness, and life.

Overview Major research and education programs to study radiation and its effects were first undertaken in the 1940's and 1950's. These programs provided systematic assessments of the immediate or genetic effects of various levels and types of radiation on both humans and animals. Most data on radiation risk before this time had been estimated from measures of effects in persons involved in diagnostic and medical X-ray irradiations or from special studies dealing with issues such as the effects of radium ingested by workers painting watch dials. The epidemiological study of the long-term effects on the survivors of Hiroshima and Nagasaki began with the establishment of the Atomic Bomb Casualty Commission, now called the Radiation Effects Research Foundation. Their studies provided initial information on a wide range of doses of ionizing radiation from many radioactive isotopes, including information on those common to the defense and nuclear power industries.

By the 1960's, comparative evaluations of health risks from radionuclides in defense and energy production included studies at each stage of these industries, from mining and production through storage and disposal of nuclear material. Insights gained from these studies permitted the correlation of results from cells, animals, and humans to provide insight into the biological impacts of radiation. Moreover, they provide the scientific information required to establish realistic exposure limits for both nuclear industry workers and the general population.

The primary unresolved issue in human health-effects studies is the effect of long-term exposure to low levels of radiation. Over the next decade the study of health effects will benefit from its first direct information as many of the workers under study complete expected latency periods (time from exposure to possible cancer onset). Any variations from population norms will provide first-hand data for drawing conclusions about radiation effects. Without this confirming evidence, health effects from low-level exposures would continue to be based on indirect information of three kinds: (1) the lack of adverse effects in the workers under study, (2) estimates obtained from the use of animals as substitutes for humans, and (3) data from the studies of Japanese atomic bomb survivors exposed to medium-to-high levels in a single exposure event. Thus, although enough data for positive confirmation may be 10 or more years away, the fact that the estimates have held year after year for the last 35 years has allowed industries involved with radiation to gain increasing confidence in the standards by which they operate.

The next sections will outline the research areas undertaken by OHER in an attempt to gain a working understanding of the potential human health effects from nuclear technologies. The complementary research efforts of radiation biology, epidemiology, and animal studies support the evaluation of public and worker exposure standards. These sections are followed by a sample of the benefits that have accrued from OHER research in human health effects.

Radiation Biology Radiation biology is the study of the effects of radiation on biological systems. The emergence of radiation biology as a major area of scientific research resulted from the establishment of the AEC and its Division of Biology and Medicine (later called the Office of Health and Environmental Research). Large-scale programs designed to examine the biological effects of atomic radiation were initiated at a number of the OHER-supported laboratories, including those at Oak Ridge, Brookhaven, Argonne, Los Alamos, and Hanford Pacific Northwest Laboratory (PNL), as well as within several nongovernment institutions, notably the Universities of California, Rochester, and Utah, and the Lovelace Foundation (Inhalation Toxicology Research Institute). A smaller program of university-based, contract-supported research was also instituted.

Undoubtedly, one of the major impacts on the expansion of biology in the 1950's and 1960's resulted from the close interaction among physicists, engineers, biologists, and physicians at the radiation biology laboratories. Interdisciplinary research and training with added emphasis on quantification were very effective in bringing about rapid advances in both basic and applied aspects of quantitative biology and medicine. The general trend towards quantitative biology can be seen in the increased emphasis placed on physics, chemistry, and physical chemistry content in biology courses taught at the university level. The value of a solid background in physical science to the biological or medical student is now well accepted.

Discoveries within the field of radiation biology have had a major impact in many areas of science: genetics, biophysics, immunology, nucleic acid structure and function, DNA repair, cell biology, and cancer research. Radiation biology research provided the basis for major advances achieved in research related to human health effects, environmental effects, and nuclear medicine, all discussed elsewhere in this report. Some additional examples will serve to illustrate the breadth of impact of radiation biology on biomedical research: basic and applied investigations in molecular biology, cellular biology, genetics, and the mechanisms involved in the development of cancer.

The continuity and diversity of life forms depend upon the replication (duplication of genetic material), the recombination (the exchange of genetic material to yield genetic diversity), and the repair (the removal of damage resulting from environmental agents or from mistakes in replication) of DNA. When DNA repair mechanisms are functioning normally, cell survival increases while the mutation rate and the probability of cancer or other abnormal changes in tissues resulting from exposure to radiation or a toxic chemical decreases. The discovery of DNA repair, a landmark achievement, was a direct outcome of OHER-supported investigations in radiation biology—in this case, research on the genetic effects of ultraviolet light.

Cell cycle studies using agents such as radioactive thymidine (^{3}H-thymidine) and radioactive iodine (iodine-125) have led to increased understanding of DNA replication, DNA repair, and the genetics and biochemistry of specific phases of the cell life cycle. In addition, many effects of endogenous and exogenous environmental agents on these cellular functions have been determined. Drawing on this research, more rational and scientific uses of chemotherapy for the management of cancer and other proliferative diseases have been formulated and adopted.

The ability to perform many of the procedures in molecular biology now common in laboratories throughout the world clearly resulted from earlier work on radioactive precursors of DNA, as well as from the development of techniques for manipulating, isolating, and analyzing radiation-damaged DNA. Today, these techniques are being put into practical use in genetic engineering for the production of insulin, growth hormones, and other biological materials of great utility to mankind. Another consequence of the early studies of DNA synthesis is the current interest in human genetic diseases associated with defects in the DNA repair mechanism or in the proteins that, along with DNA, form the genetic material of living cells, known as chromatin. Diseases of this type include xeroderma pigmentosa, ataxia telangiectasia, Bloom's syndrome, and Fanconi's anemia.

Knowledge of DNA repair and other cell cycle phenomena arose from attempts to understand radiobiological phenomena. The concepts and methodologies of DNA repair research have now been extended to two other important areas of biological research—the study of the chemical causes of cancer and aging. The connection between the chemical and radiological causes of cancer arises from the important discovery that the modes of repair of chemical damage in DNA of human cells mimic either ultraviolet damage and repair or radiation damage and repair. Hence, DNA repair is a general phenommenon, not one peculiar to radiation. Active repair of DNA in bacterial or mammalian cells treated with potential mutation or cancer-causing substances, mutagens or carcinogens, respectively, is taken as evidence of DNA damage and is the basis for several rapid tests for agents that cause harm or destroy genes. The use of bacteria that lack the ability to repair damage to DNA in such tests, for example, the Ames test, enhances by orders of magnitude their sensitivity for detecting cancer-causing chemicals.

In 1974 researchers at the Brookhaven National Laboratory (BNL) made the intriguing finding that the ability of cultured cells from different mammalian species to carry out the repair of ultraviolet-induced DNA damage increased as the life span of the species increased. Human cells are very good at excision repair; mouse cells are poor. The notion that there is a correlation between aging and DNA repair ability was derived from early experiments at Oak Ridge National Laboratory (ORNL) on the accumulation of single-strand breaks in the DNA of tissues of old mice. This area of new and fruitful research was opened up by OHER support for radiation biology and DNA repair.

Radiation biology has had massive impacts on human medicine since the late 1940's, as discussed in the section entitled "Nuclear Medicine." We can get a glimpse of its significance in another important area of medicine from two summaries on the use of bone marrow transplantation in contemporary medical treatment. Bone marrow transplants were first used as a treatment for radiation-induced damage to blood-forming cells in bone marrow. R. A. Good writing in *The New England Journal of Medicine* in 1982 said, "Indeed more than 20 previously fatal diseases can now be successfully treated with bone marrow transplantation. These disorders range from genetically determined severe combined immunodeficiency diseases to acute leukemias." Similarly, E. Beutler of *The Journal of the American Medical Association* in 1981 pointed out, "Until recently, our mind-set was that leukemia was not curable." In selected leukemia patients and under appropriate circumstances,

> *the vast majority (well over 90%) survive the transplantation procedure, and the extent of morbidity does not differ greatly from that associated with ordinary induction chemotherapy. Despite the occurrence of graft-vs-host disease and occasional relapses, the overall cure rate of this selected group of patients seems to be between 70% and 80%.*

Epidemiology of Radiation Exposure Quantitative data have been produced from epidemiologic studies of the genetic (on the germ or reproductive cells) and somatic (on the body as a whole or on cells other than germ or reproductive cells) effects observed in humans exposed to radiation. These data allow the establishment of upper-bound estimates of the genetic risk and numerical estimates of the somatic risk of such exposures. At a more basic scientific level, research in molecular epidemiology on understanding the molecular basis of predisposition toward and resistance to damage by radiation and toxic chemicals now is extremely promising. The identification of populations that are particularly susceptible or resistant to certain types of insults is not only of the greatest significance to medical sciences, but it will have a major positive impact on Federal regulatory activities by providing data for setting health standards that take into account both variations in the population and the doses to which human populations are ordinarily exposed.

The study of atomic bomb survivors in Japan has provided the best available estimates of the risk of various types of cancer resulting from exposure to external low-energy radiation. Some of the characteristics that make this study particularly useful are as follows:

1. The survivors are the only large population with a wide range of whole-body exposures, or exposure over the entire body.
2. The population was comparatively random with respect to health and work history.
3. An elaborate dosimetry program has yielded individual dose estimates for major organs.
4. The family registration system of Japan ensures 100 percent followup on mortality.

Although intensive study has been under way for over 30 years, the past decade has seen the identification of new potential cancer sites and revisions of previous estimates of risk. Most recently, a reassessment of calculated gamma and neutron dose received by individuals has led to a major change in the carcinogenic, or cancer-producing, role assigned to neutrons and to a modest revision in estimates of gamma doses.

A series of epidemiological studies designed to detect genetic effects among the offspring of atomic bomb survivors has shown no statistically significant difference between them and the offspring of groups not exposed to the radiation. The genetic studies have provided valuable assurance that the use of animal data (see section on "Animal Studies") does not seriously underestimate the effect on human populations. The epidemiological results are consistent with the mouse data and also allow us to confidently place an upper bound on the level of somatic effects in irradiated humans.

Although the study of bomb survivors was the predominant factor in developing a quantitative estimate of the effects of various levels of exposure, i.e., a dose-response relationship for radiation-induced cancer, it has inherent limitations, notably that the data were compiled from a single exposure at a high dose rate and the population samples are not large enough to define with any confidence the risk of very low dose rates. These factors made questionable the extrapolation of the dose-response curve to lower, prolonged exposures without additional information. Moreover, animal studies had shown that the results of high doses of low energy-transfer radiation (low energy particles or gamma radiation) received over a short period of time are of far more consequence than the same dose received over a long period of time. As a result, studies of industrial workers were begun by the AEC as early as 1964. The initia studies of Hanford and other DOE-contractor employees have subsequently been expanded to include naval shipyard workers and soldiers present at nuclear weapons tests in Nevada. The results to date have reinforced the low risk that would be predicted for workplace external exposures.

The AEC initiated a study of radium-dial painters subjected to radiation from internal radium deposits accumulated in the era before the health effects of radiation exposure were generally known. Radium emits high energy alpha-particles and a gamma ray. These epidemiological studies have provided the primary basis for setting all such standards for radium and for transuranic elements such as plutonium, which also emit alpha-particles and gamma rays. Epidemiological research on chronic internal exposure has more recently been expanded to include plutonium workers at several DOE facilities. Results of this ongoing work have corroborated the adequacy of current standards for these alpha emitters.

Animal Studies Important information about the risks from exposure to radiation has been derived from large-scale animal experiments. These studies determined the potential cancer or genetic effects from internally deposited radionuclides or from external radiation and revealed the importance of the rate with which the radiation is received, as well as the relative biological effectiveness of different types of radiation.

Because there was minimal human data on the effects of long-term exposure to low levels of radiation, animal data had to play a significant role in estimating guidelines for allowable human exposure to different types of radiation. Between 1956 and 1966, three large studies on mammals were conducted to determine (1) the latent effects of plutonium exposure in dogs and rodents, (2) the relative toxicity of strontium-90 and radium-226 deposited in the skeletons of humans and other mammals, and (3) the genetic effects of external radiation in mice. By 1974 ten major animal experiments were in place to determine the uptake, metabolism, dosimetry, and early and late effects of exposure to most major fission products of concern. There were also concerns about the importance of chemical forms of plutonium administered by different exposure routes and the importance of dose (quantity and rate) of external gamma ray or fission energy neutrons in the induction of late somatic or genetic effects.

Following are five examples of some of the studies developed to investigate these important issues:

1. ***Relation of Human and Animal Effects of Bone-Seeking Radionuclides.*** The radium-dial-painters study provided a quantitative epidemiological data base for humans exposed to, and carrying gradedbody burdens of, the natural bone-seeking radionuclide radium-226. By obtaining comparable data for radium-226 in a long-lived animal species (dog), a radiation effects ratio (RER) for radium-226 can becalculated as follows:

   $$\text{RER} = \frac{^{226}\text{Ra-effects (man)}}{^{226}\text{Ra-effects (dog)}}.$$

   Assuming the same interspecies relation holds true for other bone-seeking radionuclides, such as plutonium-239, and using the following expression, the data from the dog studies can be used to estimate the potential hazards from these radionuclides to humans:

   $$^{239}\text{Pu-effects (man)} = \text{RER} \times {}^{239}\text{Pu-effects (dog)}.$$

   These studies provide vital data for predicting human risks of radiogenic bone cancer from important man-made radionuclides, which are already present in our biosphere. The data derived from these experiments have demonstrated that the present guidelines are scientifically defensible for radiation exposure by workers and the general population.

2. ***Determination of Dose-Rate Effects of External Sources on Radiation Risks.*** Most of the early data on radiation risk estimation were derived from studies of people involved in diagnostic and therapeutic medical X-ray exposure. Although there was strong evidence that low dose rates or protracted radiation exposure was less harmful than high-dose-rate single exposures, no systematic assessment and

measurement of the magnitude of the dose-rate effectiveness factors had been made for either heritable or genetic effects or for delayed toxicological effects and cancer induction. OHER-supported studies showed that genetically different mouse strains responded similarly to the varying dose rates. These findings prompted studies in which gamma and neutron irradiation would be compared as a function of dose rate.

3. *Potential Health Risks in Nuclear Research, Weapons Programs, and Power Production.* Multispecies animal experiments were initiated in several laboratories to validate the acceptability of standards and guidelines for radionuclides produced by nuclear fission. Priority among the fission products was established based on their relative fission yields, their half-lives, and their propensity, due to the metabolic characteristics of the exposed animal, to be deposited and retained in specific organs of the body. These studies showed that radiation responses could be altered by different routes of exposure, by differences in localized dose and dose rate, and by other variables such as the chemical characteristics of the radioactive compound and the type of radiation produced by its decay products. Development of nuclear power reactors led to expansion of the OHER effort to include ovaluation of important radionuclides encountered at each significant stage of the nuclear fuel cycle, from uranium mining through storage and disposal of nuclear waste.

   A major fraction of OHER's research has involved animal exposures by inhalation, one of the most significant routes of exposure for products of the fission process, especially plutonium. These animal studies were instrumental in developing models describing the distribution and fate of various soluble and insoluble aerosols in the lungs, including movement to remote critical organs at different times after exposure.

4. *Determination of the Genetic Effects of Radiation in Mice.* Until 1947 estimates of the genetic hazards of radiation were based entirely upon the data derived from the fruit fly (Drosophila). Because it was essential to obtain information on a mammalian species to provide a closer correlation with man and because a genetic study requires data over many generations, a long-term, very large-scale study of radiation-induced genetic effects in mice was begun. Pending definitive results from the epidemiological studies discussed earlier, the results of the mouse studies still provide the basis for our estimation of genetic risk to humans.

   The large mouse study required the development of new techniques and methods for detecting radiation-induced mutation. One of these, the specific locus method, has found wide application in determining how mutation rate varies with changes in radiological and biological parameters such as dose rate, dose fractionation, total dose, radiation quality, sex, stage in the cell life cycle, and age at exposure. The specific locus method is also being applied to the study of the processes by which some chemicals cause mutations, called chemical mutagenesis, and to the possible effects of energy-related and other environmental pollutants.

   It was found that the mouse was considerably more sensitive than the fruit fly to the induction of mutations by large, rapidly administered (acute) doses of radiation. This result was an important factor in the subsequent lowering of recommended permissible levels for human exposure to radiation. Additionally, it was discovered that the level of mutations produced in male and female mice was different over a range of dose rates. In males this was manifested by a one-third reduction in mutation rate when the same dose was absorbed at a low, as compared with a high, rate of exposure. It was also found that the germ cell in the female mouse is so resistant to mutation induction by radiation that no significant increase over naturally occurring, spontaneous mutation rates has been detected in the irradiated animal.

These last two findings together suggested that genetic risk in man is only about one-sixth of what it was estimated to be when radiation exposure limits were based on high dose-rate results and on the assumption that females and males were equally sensitive. Although the findings did not lead to the raising of permissible levels of radiation exposure, they did provide a cogent argument for no further lowering of permissible levels.

5. *Supporting Animal Studies.* To interpret experimental results, it was necessary to understand the natural changes occurring in animals being studied, that is to study the role of aging and to gain a better understanding of the biological process of aging itself. Strong support was given to recording and analyzing specific biological parameters such as brain mass, metabolic rate, body temperature, and body mass—important parameters that correlate with and serve as actuarial predictors of longevity in animal species. The white-footed field mouse and the common laboratory mouse were particularly useful in this regard. Although these two species are similar in coloration, form, and size, the field mouse has a lifespan of nearly 8 years while the laboratory mouse seldom lives longer than 3 years. Additional aspects of aging and longevity are being explored and include immunologic factors and possible relationships between the aging process and cellular DNA repair.

Evaluation of Exposure Potential to Workers and the Public Detailed information on appropriate industrial hygiene practices was developed to ensure safe operation of industries that use radiation sources and radioactive isotopes and to ensure public safety. This information was developed through major OHER-supported research and educational programs in the areas of radiation monitoring; dosimetry and toxicology; air, water, and soil analysis; bioassay; and health risk and analysis. These are now broadly included in the field of health physics.

To evaluate radiation exposures of workers in nuclear industries, health physicists needed devices to measure radiation from external sources and bioassay methods to determine the amounts of radioactivity that may have been taken into the body. Personal dosimeters were developed, first from radiation sensitive film and then from thermoluminescent crystals. Biological assay or bioassay techniques were developed that used radiation counters that measure radiation absorbed by the body, excretion assays, and biomathematical models of the metabolism of internally deposited radionuclides. These techniques have provided working lifetime records of external radiation exposures and the amounts of radioactivity that may have been taken into the body. Exposure records are available today for most workers in industries using radioactive processes or equipment and can be used to evaluate the potential for an individual developing a radiation-related injury.

Extensive research programs were initiated and expanded to develop models needed to project the dispersion of radioactivity in the environment and its uptake and retention by people. Models are currently available to predict transport of radioactivity through air, groundwater, and soil. Other biological research programs have produced models to project the transfer of radioactive isotopes through food pathways to man and their uptake from food, water, and air.

Large research and educational programs were established during the 1940's and 1950's to study radiation concerns of the future. Graduate level training programs were begun at the University of Rochester, Harvard University, Vanderbilt University, and the University of California, among others. They were also coupled to research programs at several National Laboratories supported by the AEC. The majority of trained health physicists working in nuclear industries today are graduates of these programs.

The radiation monitoring instruments, measurement techniques, and models described above are the major tools used by health physicists in industry and Government safety programs to evaluate human radiation exposures at operating plants and facilities. They were mainly developed in DOE-supported research programs and have been used for many years to provide exposure records and risk evaluations for radiation workers and members of the general public. The nuclear industry is unique among industries that handle potentially toxic substances because of the state of development of its detailed methods to characterize or document human exposures.

Currently, about 200,000 people in the United States have occupations that involve handling radiation sources and radioactive isotopes. Their safety depends on proper application of radiation exposure standards and the abilities of health physicists to measure and record exposures. Thus, the most important uses of technology developed in radiation research programs supported by DOE and its predecessor agencies are in industrial hygiene and radiation safety.

Benefits of Nuclear Technology Research The bulk of worldwide regulatory and environmental assessment action regarding nuclear power is based largely on the body of knowledge acquired in the OHER Program.

A concrete example of a benefit of this information is to United States electric power consumers in a recent decision by Federal regulators to maintain standards in the workplace at the same level as those maintained for the past 25 years. It can be estimated what a given reduction in the worker exposure limit would cost; and, thus, what value these studies have had for the consumer/taxpayer. For example, a reduction of the annual worker exposure limit from the current 5 rem*/year to 0.5 rem/year would cost the Government and industry nearly $2 billion/year. In both commercial and DOE facilities, moreover, the increase in number of work crews required to reduce exposure times would, in turn, increase cumulative exposure because each worker receives some fraction of his or her exposure during the nonproductive time spent in removing contaminated protective gear. The greater the frequency of such changes, the greater cumulative exposure to perform the same amount of work. For a 0.5-rem/year limit, the Atomic Industrial Forum estimates an increase of 5400 man-rems/year for the power-reactor industry and an increase

*The amount of ionizing radiation required to produce the same biological effect as one Roentgen of high-penetration X-rays.

of 2300 man-rems/year for DOE's various programs. While there is substantial uncertainty in the financial evaluation of increased radiation exposure, the 7700 man-rems/year increase is certainly significant.

Because research supported by DOE and its predecessor agencies has put industrial radiation protection practices on a firmer scientific basis, these practices can readily be defended in legal actions taken against the United States Government and its contractors. OHER's research does not serve as part of Government advocacy but, rather, provides a scientific basis upon which claimants' injuries can be assessed and equitable decisions can be reached. One example involved a claim against the DOW Chemical Company, Rockwell International, and the United States Government for $200 million in damages alleged to have been caused by plutonium spilled at the Rocky Flats nuclear weapons facility between 1959 and 1965. Small amounts of plutonium were blown by the wind into neighboring lands. The claim, filed in 1975 in District Court in Denver, Colorado, was dismissed in May 1982 because the Government, and its contractors were able to demonstrate acceptably to all parties that the level of plutonium outside of the Rocky Flats facility did not represent a significant hazard.

Our understanding of the role of dose rate in risk estimation was significantly enhanced by the animal studies. Studies on mice, for example, demonstrated for the first time that for the same cumulative dose of radiation, fewer mutations and cancers are produced in animals receiving low dose rate exposures than in those receiving the same exposure at a high rate. Furthermore, it was shown that the same total amount of radiation delivered in smaller increments to mice was less damaging than when delivered as a single exposure. These data showed that mammals other than man are capable of repairing damage to cells involved in transmitting the genetic information from one generation to the next. A careful evaluation of the same endpoints from the radiation exposures of mice, dogs, and man has provided a model for the scaling of radiation effects between the species. Animal studies are also providing information on differences in radiation sensitivity as a function of the age when irradiated. The positive contribution is to provide sound scientific data that are essential for those charged with developing guidelines for the protection of human health.

The radiation biology research program and the applied studies in radiation effects continue to hold great promise of a better understanding of biological processes and of treatments and therapies for a number of human diseases. Research to date has led to a host of theories on the possible causes of genetic diseases, birth defects, aging, and cancer, as well as to advances in immunology and treatment. Much of this research may eventually resolve the question of the existence of a threshold for radiation damage.

Simple discoveries, such as the use of tritium-labeled thymidine as a DNA precursor, were instrumental in helping characterize DNA replication and recombination in mammalian cells, as well as the properties of the different phases of the cell cycle. A knowledge of such phases is important not only in the estimation of mutagenic and carcinogenic risk, but also in radiation therapy as well.

Synthetic Fuels Human epidemiological studies provide the most direct information for developing relationships between levels of exposure and health risks. However, these studies are rarely available for industrial products not already on the market, as is the case for the products of such technologies as oil shale or synthetic oil from coal. Thus, laboratory studies are generally undertaken to provide the needed information. These usually begin with studies using bacteria and mammalian cells in cultures (see Fast Test for Cancer-causing Chemicals in "Detection and Measurement of Human Health Effects") and may progress to exposures of whole laboratory animals by skin painting, inhalation, or ingestion. Because costs of these studies increase markedly with the level of complexity, most elaborate life-span studies using laboratory animals are undertaken only when the less costly cell culture assays indicate a potentially important human health concern.

Mathematical methods are also being developed to combine the results of short-term bioassay tests, whole animal studies, and human epidemiology to predict the health risks associated with new chemical substances. With these methods the toxic potential of new substances is determined through comparison with other substances that act in similar ways and for which human health risks have been measured. Human health risks can thus be estimated per unit of exposure, providing the information necessary to establish reasonable human exposure guidelines.

Research on the health risks associated with exposures to substances produced in coal conversion and oil shale recovery processes will also provide a firm basis for the development of exposure control guidelines for workers in these industries. It is important for the orderly development of safe working conditions that the health-effects research precede the large-scale deployment of fuel production facilities.

Coal Gasification Procedures have been developed and their validity demonstrated for (1) analyzing chemical toxicants in compound mixtures, (2) monitoring human and environmental exposures, and (3) mitigating exposures and their effects. These procedures have been proven effective in characterizing the toxic chemical species in the process and effluent streams of coal gasification pilot plants and process development units.

History Epidemiological information on workers in turn-of-the-century coal gasification plants (in England and Japan) and more recent experience in coking operations indicated that a coal gasification industry might present significant potential for adverse human health effects (e.g., increased incidence of lung and bladder cancer). Likewise, the tremendous amounts of coal that would be consumed in a gasification industry suggested that the entire conversion system had potential to create a number of adverse environmental impacts.

In the mid-1970's OHER initiated a broad program of health and environmental studies at operating coal gasification development units and pilot plant facilities to obtain definitive information on the potential health effects of modern coal gasification technology. These studies, which use state-of-the-art toxicological and ecological testing methods and procedures, are coordinated with and complementary to, studies supporting the development of advanced high-Btu and low-Btu coal gasification technology.

Studies to identify and characterize the extent of toxins in gaseous products from coal focused on the potentially carcinogenic organic compounds in process streams and effluents. Ecological studies addressed the effects of air-emissions, liquid effluents, and solid waste disposal. Industrial hygiene studies included workplace monitoring, medical surveillance, and evaluations of the adequacy of measures to limit exposures and effects. Finally, an initial risk assessment of coal gasification was performed.

Benefits As a direct result of the studies at pilot plants, toxicological evaluation of process streams and effluents from full-scale gasifiers can be limited to screening tests for most streams. Detailed analysis is necessary only for those streams or stream components with previously identified toxicity. This practical research has established that (1) the mutagenicity of organic compounds is limited principally to chemicals called the higher molecular weight polynuclear aromatic hydrocarbons, making it necessary to study and characterize the toxicity of less than 1 percent of the material found in most process streams, and (2) the more volatile hydrocarbons found in the process stream (e.g., naphtha with up to 1000 tons/day output) do not contain new toxins, need not come under Toxic Substances Control Act regulations, and thus will not require extensive toxicological study.

This means that it should be possible to design facilities to recover these commercially valuable chemicals rather than burn them as in-plant fuels or to dispose of them as waste materials. The evaluation of process streams for toxins has also been greatly simplified by the development of sophisticated procedures for separating the complex coal-derived products and isolating and identifying toxic chemicals. New instruments for vapors and liquids have been developed and field-tested for monitoring contamination by polynuclear aromatic hydrocarbons in the workplace. These instruments provide a simple method for directly evaluating exposure and can monitor the effectiveness of mitigating procedures, which is almost impossible without such instrumentation.

Ecological studies have indicated that the effects of atmospheric emissions on vegetation decrease with decreasing humidity. Thus, judicious site selection criteria could yield economies in emission control requirements without sacrificing air quality.

Evaluation of environmental control technologies has provided information that will permit health and safety considerations to be incorporated in process design. In a low-Btu industrial gasifier, commercially available cleanup devices have been shown to be effective in removing materials of health and environmental concern. On the other hand, solvent extraction of wastewater from tar-producing gasifiers does not completely remove all products of potential concern; further treatment may be required before discharge to the environment. Similarly, leaching of the large amount of solid waste produced in a commercial-scale facility might in the long term have adverse environmental effects even though the concentration of toxins in the waste is low.

As a result of the knowledge gained through this program, the scope of health and environmental studies required at any future full-scale commercial facilities will be greatly reduced, information on toxic substances and their location in the product or waste stream is available, validated methodologies are available for obtaining meaningful data, sophisticated procedures for isolating and identifying toxins have been developed, and many of the problems that can be prevented by careful plant design are known.

Coal Liquefaction Less costly technologies can be used to control the toxic side effects of coal liquefaction processes while still meeting health standards likely to be established for the direct coal liquids industry. The carcinogenic and mutagenic activities of coal-derived liquids from numerous liquefaction processes occur only in a fraction of the liquid product and can be reduced through process modifications.

History In the early 1970's, interest in producing liquids from coal as a means of reducing United States dependence on foreign oil sources was heightened. However, the possibly deleterious effects (e.g., lung, skin, and scrotal cancers) of coal processing and, perhaps, products were known to both industry and Government agencies interested in developing coal liquefaction processes. Great care was taken in research and development (R&D) facilities to minimize the exposure of workers to process stream materials. In addition, careful medical surveillance programs were carried out to monitor the health of workers in pilot plants. Concern by industry and Government regulatory agencies led to preliminary commercial plant designs that would reduce the exposure of workers to all process stream materials and fugitive emissions. However, there were lingering concerns that excess costs were being incurred in safety systems and that equal or better worker safety could be obtained in a more cost-effective way.

To obtain the data necessary to evaluate the potential health impacts of coal liquefaction, a broad-based research program was undertaken to examine materials from a number of different coal liquefaction processes. Substantial effort was directed toward using simple tests to screen for possible carcinogens and mutagens. Other studies investigated the oral toxicity and teratogenic potential, or the ability to cause fetal malformations, of the materials.

Benefits The tests demonstrated that coal liquefaction products with boiling points below approximately 650°F were not active biologically. This was true when the tests measured mutations in microbial changes in cells taken from mammals. Further examination showed that both the mutations and cancers observed resulted from fractions boiling above the 650°F to 700°F range. Moreover, the rates of occurrence increased markedly in fractions that boiled above 800°F.

It appeared, therefore, that mitigating procedures might be applied to a more limited set of materials than had been previously thought possible, with corresponding cost savings. For example, for a SRC-II (Solvent-Refined Coal) fuel oil blend (with boiling points ranging from 350°F to 900°F), materials boiling above 700°F represent about 25 percent of the total mass of material in the blend, and materials boiling over 800°F represent less than 10 percent. Thus, only the heaviest 10 to 20 percent of the product stream required treatment. It also appeared that hydrotreatment, a common petroleum-refining industrial process of hydrogenation using catalysts, might be effective in neutralizing the biologically active materials. Studies using the Ames assay or mammalian cell transformation assays indicate that hydrotreatment is effective in reducing the biological activity of coal-derived liquids. Skin-painting studies demonstrated that hydrotreatment dramatically reduces the potential for causing cancer.

This research also led to the definition of components acting as potential agents causing skin cancer. These are tentatively identified as compounds known as polyaromatic amines (PAA) and polynuclear aromatics (PNA). Although test data are incomplete, they provide a basis for more specific monitoring and the development of more reliable criteria for preventing worker exposure to potentially cancer-causing materials.

Research results also have an influence on the conceptual marketing strategy for coal liquids. An initial approach was to market the high-boiling materials as boiler fuels. As a result of the research, a second strategy has been identified, namely to market products with boiling points below 750°F for use without further treatment. Under this approach, the higher boiling materials would be considered for use as in-plant energy sources or as candidates for hydrotreatment to lower their boiling points.

The substantial difference between the capital and operating costs of hydrotreating all versus part of the material with high boiling points (heavy distillate) provides the basis for quantifying a portion of the potential benefits associated with OHER research. Four sets of capital and annual operating costs developed by the Chevron Research Company for the SRC-II process (a nominal 50,000-barrels/day plant) were studied, including hydrotreating the whole heavy distillate and hydrotreating only that fraction of the heavy distillate boiling above 750°F. For the Phase Zero design, SRC-II produces about 11,000 barrels/day of heavy distillate product. Material boiling above 750°F amounts to 2700 barrels/day. The estimated cost savings per year for a single SRC-II plant vary from $98 to $174 million for capital costs and from $7 to $14 million for annual operating costs. The projected cost savings per barrel of product produced are in the range of $0.69 to $1.14.

Risk Analysis Risk analysis is a system of principles, practices, and procedures that uses the information generated in scientific experiments to estimate the potential health and environmental consequences of man's activities. It is this measure, a probability or chance of an effect occurring, that is needed by policymakers, regulatory bodies, and insurance groups to formulate goals, criteria, and standards. Such estimates have proved particularly useful where atmospheric particles pose the principal concern, as in the exhausts of automotive diesels and electric power plants. Moreover, what began as developing methods for estimating the health effects of particles and sulfates found application in a wide range of analyses of the risks of other pollutants.

Evaluation of Health Risks from Atmospheric Particles A comprehensive body of information is being developed to evaluate the health risks associated with the inhalation of atmospheric particles released from energy-related industries.

The human health risks associated with exposure to atmospheric pollution depend on many factors, including the physical and chemical composition of the pollutants, their transport and transformation in the environment, the amounts that may be inhaled or ingested by humans, and their toxicity. DOE-supported research is playing an important role in identifying the pollutants of greatest concern, the manner in which they can enter the body, and their potential for causing adverse health effects. The research provided methods for characterizing and evaluating emissions from different types of coal combustion plants, coal conversion processes, oil shale recovery, and the use of petroleum fuels in diesel and gasoline engines. In some cases, new instruments were invented, for example, a family of particle samplers for use under normal atmospheric conditions and at high temperatures and pressures. New techniques were also developed for chemical fractionation and identification of pollutants and for characterization of their toxicities.

History Work dealing mainly with radioactive aerosols began in the late 1950's at the University of Rochester, PNL, and the Lovelace Fission Product Inhalation Laboratory (now the Inhalation Toxicology Research Institute). This research was expanded after 1970 to include studies of aerosol particles originating from many different energy-producing, consuming, and conservation activities. These studies have examined the ranges of particle sizes that can be inhaled by humans and test animals, to ascertain the fractions that deposit in the respiratory tract, and the potential mechanisms of their toxicity. Several such studies are now under way but will require several years to complete because lifetime observations of large groups of laboratory animals exposed to the toxic substances are necessary.

Each research project evaluates a single energy technology and estimates the risks resulting from human exposures to its products, by-products, and waste products. This research integrates diverse types of information, most of which has been developed in DOE-supported health and environmental research programs, on pollutant sources, characteristics, movement through the environment, human exposures, and health effects. These analyses are expected to provide the information necessary for cost-effective regulation of future energy industries, including models of exposure and risk from atmospheric particulates.

At present, the estimation of health risks from particles emitted by energy technologies is a complicated and uncertain process because of incomplete information regarding which components of atmospheric articulate matter are toxic and may cause illness or death in humans. As the toxicity of atmospheric particles becomes better understood, this information can be combined with knowledge of the atmospheric dispersion of particles to decrease the uncertainty involved in projecting the health risks that energy technologies might pose to the general population.

Benefits Two major benefits of research to evaluate the health risks associated with exposure to atmospheric particles follow.

1. *Development of the scientific information base.* The fossil fuels research program has focused mainly on characterizing emissions from electricity-generating power plants and light-duty vehicles used in road transportation. These two categories of energy use account for nearly 50 percent of the emissions of regulated pollutants in the United States. The physical and chemical characteristics of these emissions are now well known.

   The research program has also contributed greatly to an understanding of the deposition, retention, and health effects of atmospheric pollutants in general. It is now known that future regulations should be aimed at controlling respirable-size particles, that is, those with aerodynamic diameters below 10 microns. It is also known that sulfur dioxide emissions contribute greatly to the formation of sulfate particles, which are mostly in the small respirable particle-size range. Automobile emissions have also been shown to be respirable. This knowledge, along with the ranking of the toxicity of various respirable particles, is crucial to the development of cost-effective pollution control guidelines.

2. *Development of atmospheric dispersion models.* An important aspect of evaluating the health and environmental impacts of new pollution sources is projecting the atmospheric concentrations of pollutants in nearby populated areas. This must be accomplished before new industrial sources are permitted. Mathematical models have been developed for projecting the atmospheric dispersion of pollutants; an example of these efforts is the *Handbook on Atmospheric Diffusion* published in 1982 (Steven R. Hanna et al., DOE/Technical Information Center, DOE/TIC-11223). Al-

though the value of these research programs lies in the development of new knowledge, it appears reasonable to assume that the enforcement of air quality standards would be on a "trial-and-error basis" if acceptable means of projecting environmental dispersion of pollutants were not available.

Evaluation of Public Health Risks from Diesel Engine Exhaust The public health risks associated with exposure to diesel engine exhaust were evaluated based on information on the physical and chemical characteristics of diesel engine exhaust, the transport of particles and gases in the atmosphere, and the potential health effects of diesel emissions. Health risks were stated in terms of the increased probability of persons living in congested urban areas developing chronic respiratory diseases or cancer. This risk evaluation is being used to focus related health effects research programs on areas where uncertainties remain about the effects of emissions from light-duty diesel vehicles.

History The attraction of diesels is largely that they achieve 10–25 percent higher fuel efficiencies than equivalent-sized gasoline engines and, thus, can make an important contribution to reducing U.S. dependence on foreign sources of oil. However, because current diesel engines emit more visible smoke and odors than gasoline engine vehicles, concern has been expressed that they may also involve new health risks. Indeed, particles emitted by diesel engines have been found to contain small amounts of known cancer-causing chemicals, which also have been shown to be mutagenic when tested in cell cultures. These particles are small enough to be inhaled by humans and deposited in the lungs. Although these are both signs of a potential health risk, epidemiological studies of workers who were exposed to high concentrations of emissions from diesel buses in garages showed no detectable increase in lung cancer incidence.

To understand this apparent anomaly, mathematical models were used to predict future air concentrations of diesel exhaust in congested urban areas. Relationships between exposure concentrations and health risks were developed by combining the results of short-term bioassay tests, whole-animal studies, and human epidemiological studies. Because human epidemiological studies of workers exposed to diesel exhausts were not sensitive enough to detect changes in cancer rates of the general population, the mathematical models used results of human epidemiological studies of populations exposed to coke-oven emissions, cigarette smoke, and urban soot. All of these represent exposures to the combustion products of fossil fuels that are similar to diesel emissions in their physical and chemical characteristics.

Overall, the health risk evaluation concluded that future diesel light-duty vehicles are not likely to increase significantly the risks of developing respiratory diseases or cancer over those already present from atmospheric pollution. The projected risks were also much less than those associated with cigarette smoking or exposure to levels of cigarette smoke that are commonly found indoors. The potential reductions in health risk that could be achieved with pollution controls on diesel vehicles were also evaluated.

Benefits The analysis performed for OHER is being used to (1) guide the development of research programs aimed at directly measuring the relationships between levels of exposure and risk, (2) identify populations that may be at greatest risk from future diesel emissions, and (3) formulate cost-effective emission control standards for future light-duty diesel vehicles. The health risk analysis was incorporated into the Environmental Protection Agency's (EPA's) summary publication *Toxicological Effects of Emissions from Diesel Engines* [J. Lewtas, *Developments in Toxicological and Environmental Science* 10, 1982 (Elsevier Science Publishing Company)].

The health risk analysis indicated that if 20 percent of the light-duty vehicles in the United States were to use diesel engines, fewer than 400 lung cancers/year would likely occur as a result of exposures to diesel engine exhaust—even if no further emission controls were applied to reduce particulate exhaust. Fewer than 200 lung cancers/year are projected if the proposed post-1985 emission standards reduce current particulate emissions by about 50 percent. This increased incidence would be a small fraction of the 100,000 lung cancers that already occur in the United States each year.

Thus, the research program developing risk analysis for the health effects of diesel engine exhaust has provided information that can serve as a basis for the cost-effective regulation of vehicle emissions.

Evaluation of Public Health Risks from Atmospheric Sulfates A probabilistic health-damage function that yielded a "best" estimate for increased mortality as a result of exposure to atmospheric sulfate particles, which included a confidence interval expressing the range of uncertainty of the estimate, was derived.

History Of the various pollutants produced in the combustion of fossil fuels, the chemically transformed products of sulfur dioxide and atmospheric sulfates have been of particular concern with respect to potential increases in human mortality. Numerous epidemiological studies have been conducted, generating a broad range of sometimes conflicting results. These studies were assessed for scientific validity and then aggregated into a single probabilistic function that expresses the uncertainty of the information available.

This probabilistic health-damage function has now become standard in the air pollution health impact literature, and the general methodology has been extended to a broad range of risk assessment and policy analysis applications. The function has served as an important tool in educating policymakers and the general public regarding the potential health impacts of future emissions. A recent state-of-the-art assessment of fossil fuel combustion stated that the probabilistic function might be regarded as the best available indication of the magnitude of the effect of air pollution on health. In addition, the function was selected by the Office of Technology Assessment for use in estimating the health effects of sulfur dioxide emissions.

Benefits Concern about the health and environmental impacts of sulfur dioxide emissions has been evident in bills placed before the United States Senate. One such bill required a reduction of sulfur dioxide emissions from about 22.5 million to 12.5 million tons/year in the states bordering on and east of the Mississippi River (a reduction of about 45 percent of 1980 emissions), while another required a total emissions reduction of about 8.2 million tons annually in these states. Although these bills were aimed primarily at reducing the environmental damage caused by acid rain, they also have implications for human health. In response to these bills and hearings on revision of the Clean Air Act of 1970, the Office of Technology Assessment prepared a technical report for Congress on sulfur dioxide emissions. The health impacts portion of that report is based on the probabilistic sulfate/particle damage function. The cost of the emissions reductions specified in the first bill was estimated to range from $3.9 billion to $4.9 billion/year (1981 dollars) and the cost of the second bill to range from $2.6 billion to $3.1 billion/year. In a separate study the Congressional Budget Office estimated that simply maintaining current sulfur dioxide emissions standards would cost $36.5 billion (1981 dollars) in capital costs and $15.4 billion in annual operating costs.

To bring these numbers into perspective, the probabilistic sulfate damage function was used to estimate the health impacts of both bills. The reduction in excess deaths that might result from a reduced level of emissions was calculated along with the investment costs required to meet the reduced levels. The cost per death averted was found to vary in the 90 percent confidence range, from $59,000 to infinity, with the median at $180,000 to $230,000.

With a method available to quantify potential sulfate health effects, both proponents and opponents of emissions-control legislation are able to generate widely varying, but defensible health-impact estimates to support their respective positions. General acceptance of the probabilistic damage function enables decision makers to place extreme estimates in perspective and provides them with a common basis for comparing alternate regulatory options and approaches.

Responding to Hazardous Events Events in recent years, such as the reentry of Cosmos 942 and the atmospheric testing of nuclear weapons by foreign powers, have led to the development of a capability to react to such possible emergencies and evaluate their consequences. Two complementary systems that provide such a capability were developed under the OHER research program and are operational today. Both were initiated in the 1960s because of concern about fallout from atmospheric testing of nuclear-weapons.

Atmospheric Release Advisory Capability The ARAC is a validated system for predicting the transport and dispersion of substances released into the atmosphere. ARAC provides real-time analysis and interpretation of the dispersal of atmospheric releases of potentially harmful substances that are used to support on-site decisions. Output containing position- and time-dependent concentrations is provided by telephone lines to user terminals, telecopiers, and computers.

ARAC can independently predict the dispersion of materials released simultaneously from several locations. The real-time estimation results from a prediction of the concentration of the toxic material in the atmosphere. ARAC includes (1) the ability to use a variety of dispersion models that range from complex to simple; (2) the capability to include terrain effects; (3) a centralized computer facility with access to terrain data for any location in the United States; (4) the ability to use terrain information from outside the United States; and (5) access to real-time data on local weather conditions and winds aloft.

Inputs to ARAC are (1) the types of substances released, (2) the quantities of material released over time, and (3) the altitude of the release. If these factors are not known quantitatively, preselected approximations can be used in calculations. With these inputs, supplemented by current meteorological data and the internal terrain data base, ARAC can initiate its predictions. The ARAC system is activated through direct requests from ARAC sites and through DOE headquarters for non-ARAC sites.

Those users who are directly connected to the ARAC system are able to make faster and more accurate predictions. User costs vary according to equipment availability, software, and interface but generally range from $10,000 to $55,000 (not including manpower costs) for initial installation and 4 to 5 months of operation.

History The ARAC project was initiated as a result of AEC's concerns regarding the fate of radioactive debris from nuclear tests in the 1960's. Originally, the project focused on fallout and long-range transport and diffusion (thousands of kilometers) to ensure that the United States did not violate international agreements by nuclear debris from the Nevada Test Site crossing National boundaries. This capability was improved, verified by measurements, and expanded to include real-time predictions.

In 1972 the AEC decided to develop a real-time assessment capability for accidental radioactive releases from industry. The ARAC project was initiated by Lawrence Livermore National Laboratory (LLNL) in 1973. Currently, ARAC is being upgraded to state-of-the-art technology, and the staff is expanding to 24-hour coverage for Federal and state emergency response support.

Benefits ARAC is supported directly by subscribers who are concerned about both nuclear and non-nuclear releases. ARAC's subscribers include the following agencies:

1. *DOE*. Several DOE sites are tied directly to the ARAC system: Savannah River, Rocky Flats, Mound Laboratory, LLNL, and Sandia National Laboratories Livermore (SNLL).
2. *Department of Defense (DOD).* DOD was scheduled to have about 50 sites tied into ARAC by 1984.
3. *Federal Aviation Administration (FAA).* The FAA found ARAC to be very responsive in providing input for the development of air traffic advisories subsequent to foreign atmospheric nuclear tests.
4. *Federal Emergency Management Administration (FEMA).* FEMA provided support for New York and California and the commercial nuclear power plants at Rancho Seco and Indian Point to tie into ARAC. ARAC will be used to provide calculations of estimated dispersion for use in emergency planning.
5. *Environmental Protection Agency (EPA).* ARAC provided EPA with an independent (versus power company) source of information during the controlled krypton release at Three Mile Island (TMI) in July 1980.
6. *Nuclear Emergency Search Team (NEST).* DOE's NEST relies on ARAC for assessments associated with nuclear extortion threats.

ARAC provides analyzed information in circumstances where the paucity of data could lead decision makers to overrespond, resulting in an unnecessarily expensive emergency evacuation, or underrespond, leading to a compromise of public health and safety. To date almost all of the ARAC applications either indicated no threat to public health and safety, thereby avoiding unnecessary evacuations, or were used in managing the release to minimize overall risk.

An example of a major benefit of the use of ARAC was at the TMI nuclear power plant. Even though TMI was not tied into ARAC, DOE put the system into service. ARAC was operational during the first few days of the accident and provided dispersion calculations to the DOE Emergency Operations Center, the DOE emergency-response site commander, and Nuclear Regulatory Commission (NRC) representatives. The ARAC calculations indicated that an evacuation of the population around TMI was not necessary. This evaluation was consistent with other calculations and recommendations; and, therefore, no general evacuation was ordered. ARAC also supplied the FAA with dose calculations for the Harrisburg airport, which allowed officials to avoid closing the airport. In addition, ARAC was employed to help manage the controlled release of radioactive krypton in July 1980 by tracking the release and advising EPA regarding the best ground sites for portable monitors and routes to be flown by sampling aircraft. Good agreement was found between the model calculations and the observations. Fewer monitoring stations were required because of ARAC's use. ARAC was also used in a postaccident detailed analysis of population dose around TMI for the President's Commission on the accident.

Less tangible but very important benefits have been reported by DOE site users. Specifically, ARAC has been of great benefit in assuring local, state, and Federal officials responsible for protecting public health that they have an adequate capability to respond to accidental releases. Some of the DOE users have conducted public tours of their ARAC site facilities, receiving press and television coverage.

Fallout Forecasting Fallout forecasting is a system for collecting data on nuclear detonations, alerting users of nuclear events, and providing forecasts of the atmospheric spread of the radioactive debris. The National Oceanic and Atmospheric Administration (NOAA) is responsible for providing the forecasts to users. To formulate these forecasts, NOAA uses meteorological input primarily from the Air Force and DOE.

The detonation of a foreign nuclear device during peacetime triggers a coordinated Federal response to ensure maintenance of public health and safety. Through a multiagency memorandum of understanding, the following responsibilities have been established:

1. NOAA collects data from the Air Force and DOE to develop the official fallout forecast; this serves as the basis for all public announcements on the movement of airborne radioactivity and areas of potential rainout of nuclear debris.
2. The Air Force provides classified data to NOAA on nuclear debris samples, including the location, time, altitude, and concentration of airborne samples.
3. DOE gathers information on the nature of the nuclear detonation (such as location, time, yield, and height) and reports this information to NOAA for input to the fallout forecast. DOE also provides NOAA with advisories released by its ARAC center at Livermore, California. Data collected from radiation measurements at DOE facilities are made available to user agencies.

History OHER has sponsored fallout research at the NOAA Air Research Laboratory since 1952. The fallout forecasting system was developed in response to general public concern about the potential hazards of foreign nuclear detonations. It was a natural outgrowth of the Laboratory's research in atmospheric transport and dispersion, which became the focal point of the forecasting when the interagency fallout response team was formally established in 1976. Since that time the fallout forecasting element of the research program has cost approximately $300,000. OHER currently provides funding as necessary to maintain its operational status.

Benefits The primary benefit of the fallout forecasting is its triggering of a network to alert officials in radiation-sensitive industries. Once the news of a nuclear event is released, NOAA notifies the National Association of Photographic Manufacturers (NAPM), EPA (usually a joint announcement with DOE), FAA, NRC, the Food and Drug Administration (FDA), and FEMA.

Each organization responds according to the needs of its users. Generally, the actions taken are preventive in nature. The kinds of problems prevented and the actions taken as a result of the alert network and subsequent forecasts are user-specific.

1. The photographic industry is concerned about potential damage to sensitive materials during manufacture. The most sensitive are scientific plates and X-ray film. NOAA alerts NAPM, which in turn notifies 16 member-plant officials (DuPont, Kodak, 3M, and Polaroid, for example). If radiation levels rise sufficiently, filtered air and water may be recirculated to avoid contamination from external sources. Only in the early 1950's (from United States tests) has fallout been severe enough to damage materials and cause a production shutdown.
2. The EPA (a) disseminates to Federal agencies and the general public predictions from NOAA on pathways of contaminated air-mass movements over the United States and areas of possible rainout of radioactive materials and (b) activates the standby portions of the Environmental Radiation Ambient Monitoring System (ERAMS). EPA also recommends necessary radiation surveillance or protective actions to appropriate state agencies.
3. The FAA uses data from NOAA, the Air Force, and DOE to develop air traffic advisories for appropriate air traffic control centers, airman's information centers, and airlines regarding airspace that should be avoided because of potential or actual radioactive contamination. These advisories depend most heavily on Air Force and ARAC information.
4. NRC is concerned about the possibility that fallout may trigger on- or off-site monitors at nuclear facilities. Local severe weather following a nuclear test can cause monitors to show significant increases in radiation levels that can be confused with a radiation leak from a reactor. NRC alerts all reactor facilities and has thereby avoided costly power plant shutdowns that might last from hours to weeks at a potential cost of $500,000/day.
5. FDA receives information from NOAA regarding the probable location of fallout contamination and consults with EPA concerning radiation surveillance and protective actions. FDA then provides guidance to state and local Governments regarding appropriate responses for evaluating and preventing hazardous radioactive contamination of foods and animal feeds, as well as guidance on the control and use of such products should they become contaminated.

Detection and Measurement of Human Health Effects

No area of science can develop very far without special tools, methods, and instruments. During the early stages of a science, observation with available instruments is usually sufficient. At some point, it becomes necessary to measure events that have not been measured before. A new technology often provides the means of developing new, more efficient or more cost-effective instruments that find applications outside the original thrust of the research.

The instruments developed in OHER programs have found specialized applications in hospitals and clinical laboratories, research laboratories, Government, and industry. They have brought true automation, as opposed to mechanization, to the areas of cell counting and blood-chemistry analyses. The methods and procedures of short-term bioassays, fast tests for screening materials for potential cancer-causing agents, have revolutionized the field of testing new chemicals for potential hazards.

Instruments originally designed to measure radiation doses to biological systems are now found in operating power reactors and metal recovery plants, as well as in the delicate interior of electron microscopes. The concepts of personal badges and on-the-spot dosimeters are providing new ways to further increase employee safety in chemical processing facilities. The United States has a way to track and measure the path of dangerous substances released to the atmosphere should an accident or mishap occur.

In the 1960's the emphasis of environmental research shifted to the support of a civilian nuclear industry, and research efforts were directed toward perceived problems of nuclear power plants. Although all types of power plants release heat to the rivers used to supply their cooling water, the effect of the increased heat releases from the larger nuclear power plants needed to be understood. Plans to construct ocean-cooled, off-shore reactors focused research on the Continental Shelf and near-shore areas and provided valuable information for nonnuclear energy development, such as ocean thermal energy conversion (OTEC), and information necessary to evaluate ocean waste disposal. Research in the cycling of transuranic elements (manmade elements heavier than uranium, primarily plutonium) in the environment turned to the concern about their potential uptake by crops such as wheat, corn, soybean, and root crops.

Efforts to understand the impact of radioactive materials inadvertently introduced into the ecosystem by nuclear bomb tests led to a clearer understanding of how ecosystems operate. The controlled use of radioisotopes to further this understanding has increased our knowledge of the fate of nonradioactive hazardous waste, the metabolism of plants, and many other subjects.

The extremely high detectability of radioactive atoms makes them easy to trace as they move through nature's cycles and migrate from one place to another. Their known decay rates, decay products, and ratios have led to greater understanding of physical, biological, and climatic processes over whole ecosystems and of biological and life processes at the microscopic level. This use of radioactive tracers enabled man to understand the process of photosynthesis vital to plant growth and food production.

In the 1970's health and environmental research in AEC and its successor agencies broadened to support all energy sources and uses. Basic research on toxic substances and cancer-causing agents focused on applying known methods to new substances. New, unique concerns, such as reclaiming of land affected by strip mining, were brought forward to be addressed and solutions identified.

Cell Sorting and Blood Analysis
Two devices for biological analysis widely used in laboratories, hospitals, and clinics are the flow cytometer and the centrifugal fast analyzer. The flow cytometer was developed in 1965 to distinguish cells damaged by radiation from normal cells. Since then, the methods used for cell sorting and their applications have continued to increase. Today the flow cytometer is used routinely for performing complete blood counts (its greatest single application), detecting cancer and monitoring its treatment, detecting genetic abnormalities, and isolating specific chromosomes for analysis of their genetic composition.

The centrifugal fast analyzer also had its beginnings in the search for tools to measure radiation effects in humans. The analyzer, which exploits advances for processing uranium made in centrifuge technology in the 1960's, can handle a large number of samples for automated analysis simultaneously. It is used principally to test blood and other body fluids for diagnostic purposes.

Flow Cytometry The flow cytometer characterizes and sorts individual cells, permitting the measurement of cellular properties and changes in those properties on an individual rather than on a population-average basis. The cells are suspended in a fluid droplet stream flowing past one or more optical or electronic sensors that measure cell characteristics. Typically, for characterization, a cell is stained with a fluorescent dye and passed through a focused laser beam. The fluorescent light emitted from the cell is analyzed and recorded. Cell sorting is a related procedure in which droplets with particular characteristics in the stream are charged electrostatically and then diverted. This separates relatively pure populations of the selected cells from the main sample.

The advantages of flow cytometry and cell sorting over other techniques include:

1. Rapid analysis of single cells and subcellular components (10,000/second versus about 100/minute with a microscope),
2. Statistical analysis of large numbers of individual cells,
3. Rare cell identification (one cell in 10 million can be detected),
4. Greatly enhanced resolution (the 9 percent difference in the DNA content of human male versus female cells can be measured),
5. Simultaneous analysis of many parameters of individual cells, and
6. Sorting of selected cells at rapid rates.

History The first device capable of separating biological cells was developed in 1965 by M. J. Fulwyler at Los Alamos National Laboratory (LLNL) as part of research into the effects of plutonium radiation. The flow cytometer was developed to provide a means of rapidly scanning for and separating cells damaged by radiation. Further developments in the analysis of cell populations were based on optical phenomena such as absorption, light scattering, and fluorescence. The first sorter based on fluorescence analysis was developed in 1972. Almost simultaneously, a multiparameter cell/particle separator was developed. Recent developments in the field of flow cytometry and flow sorting have stressed the use of new or improved sensors for cell physical and chemical properties. Analytical capabilities such as the development of low-resolution morphological information (cell and nuclear size, chromosome length, and location of the chromosome constriction) offer the potential to detect important genetic defects and low-level background mutational events.

Since 1964 at Los Alamos and 1972 at LLNL, flow cytometry R&D has totaled about $6.5 million (1982 dollars).

Four companies currently offer flow cytometry systems at an average cost of about $100,000 per system. The number of instruments in place is estimated at 350. All companies contacted believe that there is a strong growth market for flow cytometers and are investing in new developments.

Benefits The flow cytometer cell sorter, originally intended to separate radiation damaged cells from normal cells, has been used extensively as both a biological and clinical research tool. Its major commercial potential, however, lies in its capability for automated diagnosis and economical population screening in the fields of hematology, immunology, cancer diagnosis, and genetics.

More recently, improvements in

the method have permitted the creation of a chromosome-specific DNA library which scientists believe will advance the course of human genetics by a decade; an advance which will certainly be a major step forward in the diagnosis and treatment of genetic diseases.

1. *Hematology.* Complete blood counts, which are performed routinely in the clinical laboratory, represent the single largest current application of flow cytometry. Several dedicated, single-purpose commercial machines have been developed for this purpose. Reticulocyte and platelet counting are examples of two recent developments that are moving immediately into the clinical consulting laboratory. The efficacy of diagnosis and radiotherapeutic and chemotherapeutic treatment of leukemia is being assessed by flow cytometry.
2. *Immunology.* The clinical significance of circulating monoclonal B-lymphocytes in non-Hodgkin's lymphoma has recently been demonstrated. Accurate monitoring of new patients and those in remission is being performed, and definitive markers useful in determining the results of therapy and the prognosis for relapse have been developed.
3. *Oncology.* Considerable effort has been directed to modifying the basic flow cytometric instrument to allow automation of Pap smear analysis for detecting cervical cancer. The objectives are to reduce costs, increase the information content and statistical reliability of the tests, and increase the number of early detections.
4. *Genetics.* Several genetic abnormalities involve chromosome duplication beyond the normal human complement of 46 chromosomes. Flow cytometry is used not only to detect these gross changes in the number of chromosomes, which typically result in severe mental retardation, but also to detect more subtle polymorphic events that promise the first means of diagnosing several inheritable diseases.

Centrifugal Fast Analyzers The centrifugal fast analyzer is an instrument used for medical diagnostic purposes to perform routine and special blood chemistry tests in hospitals, clinics, and research laboratories.

The centrifugal fast analyzer tests multiple samples simultaneously. It is built around a flat rotor with numerous sets of wells arranged radially. Measured quantities of the samples and reagents are introduced into individual wells toward the center of the rotor. Centrifugal force mixes each sample and its reagent and moves them into transparent reaction cells at the periphery of the rotor. During each revolution a time-synchronized measurement is made of light transmittance, color, fluorescence, or other relevant property. The course of the chemical changes in each reaction cell is monitored by an on-line computer, and analytical results are developed simultaneously for all samples on the rotor. The resulting data are stored, interpreted, and provided to the laboratory technician very rapidly. One run of the analyzer performs the same analysis on from 1 to 42 samples.

History R&D of the centrifugal fast analyzer was an outgrowth of National Laboratory expertise in biological sciences and separations science. The original funding for the project was shared by the National Institute of General Medical Sciences and the AEC. The original name of the device, GeMSAEC, is an acronym of these two contributors. The National Aeronautics and Space Administration (NASA) provided support from 1974 to 1976 for a zero-gravity centrifugal fast analyzer. Invention of the centrifugal fast analyzer is attributed to Dr. Norman G. Anderson while he was Director of the Molecular Anatomy Program at ORNL in 1968.

The original GeMSAEC system received the Industrial Research Magazine IR-100 Award as 1 of the 100 most significant new technical products of 1969. A second IR-100 Award was awarded in 1977 for the portable, miniaturized, centrifugal fast analyzer developed at ORNL.

Transfer of the analyzer to industry occurred very rapidly. In late 1968 and early 1969, representatives of Electro-Nucleonics, Inc., Union Carbide Corporation, and the American Instrument Company applied for and were granted royalty-free licenses from AEC to commercially produce a centrifugal fast analyzer. Today, five domestic companies sell centrifugal analyzers. Both industry and DOE researchers have made major contributions to its continued development analyzer; for example, improved sample handling, miniaturization, and microchemistry techniques to save reagent costs and laboratory workspace and permit improved blood analyses in areas such as pediatrics and geriatrics, where only small samples are obtainable.

Benefits Major markets for the centrifugal fast analyzer are hospitals and laboratories with low-to-medium daily test volumes. These include small-to-moderate-sized hospitals, specialty laboratories in large hospitals, and commercial laboratories. Major advantages of the centrifugal fast analyzer are its throughput capacity, flexibility to perform any type of assay, concurrent ability to perform economically single tests and batches of tests, and ability to perform emergency tests. At the time of its introduction, the centrifugal fast analyzer represented a 25 to 50 percent cost savings over the discrete analyzers then available. The centrifugal fast analyzer also represented an 80 percent cost savings over the manual methods that predominated in small-to-medium-sized hospitals. Then, as now, existing continuous-flow analyzers perform a fixed battery of tests (a "profile") for less cost than a centrifugal analyzer, but this economy is only obtainable by a laboratory that has a high enough volume of tests to justify purchasing the larger, more expensive continuous-flow instrument.

The significant benefits arising from the development of centrifugal fast analyzers include:

1. Introduction of true automation to clinical chemistry (as differentiated from mechanization);
2. Improved precision for certain tests, thus eliminating the need to retest;
3. Availability of test techniques not readily available with other equipment;
4. Data reduction in "real time" using an on-line computer;
5. Flexibility to serve institutions having small-to-medium testing loads; and
6. Cost savings to users.

Sales of the centrifugal fast analyzer are estimated by industry sources to be at least 500 units/year, amounting to approximately $25 million/ year. Industry sources indicate that the current number of centrifugal fast analyzers in operation is about 4000 in the United States and as many as 10,000 worldwide at purchased prices ranging from $20,000 to $70,000. While there are no statistics on the number of tests performed with the analyzer, two estimates are available: (1) approximately 175,000 tests per year per analyzer and (2) 10 to 25 percent of the 2 to 4 billion clinical chemistry tests performed in a year, probably closer to 10 percent of the total tests.

Owners indicated that they save 10 to 30 cents/test performed on centrifugal fast analyzers, mostly in reagent costs. Applying these factors to 300 million tests/year yields the estimated savings of $30 to $90 million/year.

Fast Test for Cancer-Causing Chemicals Short-term cell bioassays are used as inexpensive, fast screens prior to more costly animal tests in screening chemicals for cancer-producing or cell-altering characteristics. A number of tests are included within the scope of short-term cell bioassays.

One of the most widely used is a test using special strains of the bacterium *Salmonella* developed by Dr. Bruce Ames of the University of California at Berkeley. The uniqueness of this test involves the use of a mutant strain of this bacterium that is unable to produce the amino acid histidine, which is necessary for its reproduction. If the chemical being screened causes the organism to undergo a genetic change that allows it to produce histidine and, therefore, reproduce itself, then the chemical is considered a mutagen and potential cancer-causing agent. The mutational potency of the chemical under test is expressed in terms of the number of growing bacterial colonies that are observed after a period of incubation. The equipment required is minimal and a single technician can perform a number of tests in a day.

Because a negative Ames test does not absolutely ensure that a compound is inactive in humans, a "tiered" strategy in which the next levels of testing may include mammalian cells in tissue culture and acute animal studies is often employed. Although not quite as simple or inexpensive as the Ames test, such assays are still orders of magnitude quicker and cheaper than long-term, whole-animal testing.

Chromosomal aberration and sister chromatid exchange measurements are common bioassays performed with cultured mammalian cells. These assays are run either on cells grown in tissue cultures or on bone marrow cells, spermatogonia (a cell structure that precedes development of a sperm), or lymphocytes (a white blood cell formed in lymph nodes and several other organs) from experimental animals and human donors.

History Although short-term cell bioassays are most commonly used for measuring the response to chemical agents, the majority were developed from radiation studies sponsored by OHER. Their roots lie in two areas of investigation in radiation biology—chromosomal effects and genetic toxicology.

Scientists in the OHER-supported laboratories were the first to realize that the induction of chromosome aberrations—other than normal changes in genes manifested as mutations caused by the abnormal breaking and rejoining of chromosomes—could be used as a biological dosimeter. This was first demonstrated by exposing cells from a plant that is extremely sensitive to radiation damage to radioactive clouds during the atomic bomb test, Operation Greenhouse, in 1951. Later it was found that chromosomal aberrations in lymphocytes could also be used to measure dose. Additional studies, combined with advances in the science of somatic cell genetics, were instrumental in developing the mammalian cell assays noted above.

Genetic toxicology—the study of the nature, effects, and detection of radiation and chemicals on genes and, thus, on the characteristics passed from one generation to another—is a new field of science that developed from the discovery of DNA repair. Studies by Rasmusson and Painter at the Radiobiological Laboratory, University of California at San Francisco, in the 1970's demonstrated that exposure to radiation (and other toxins) caused some DNA to undergo unscheduled DNA (repair) synthesis (UDS), and that this UDS is quite separate from the normal synthesis process in DNA. This observation forms the basis of the commonly used UDS assay. The ability to construct and characterize bacteria with deficient DNA-repair mechanisms was a crucial step on the path to the Ames test.

Benefits The testing of new products using short-term cell bioassays has resulted in reduced costs and increased productivity. Many different new substances have been created and introduced to the environment in recent years, some of which have the potential to cause genetic damage. Before the early 1970's, animal testing was the only accepted means of evaluating a substance for carcinogenic activity. With the advent of the Ames test and other short-term cell bioassays, however, it has become possible to test substances for mutagenic or carcinogenic potential far more rapidly and cheaply. The Ames test, for example, presently costs $1000 to $1500 and takes only 48 hours. These bioassays are used routinely by many drug and chemical firms to screen substances for potential mutagenic activity before large expenditures are made to develop them into marketable products.

A measurable benefit of the Ames and similar tests is the amount of money manufacturers save by avoiding the development of potentially hazardous products. Because drug and chemical firms are the most active users of short-term bioassays, a very rough estimate of benefits can be developed based on calculating the amount of development money saved as a result of prescreening:

$$A = \left(\frac{D \times Fm}{1 - Fm} - T\right)$$

Where

A = net annual benefits,
D = annual R&D outlays by drug and chemical firms,
Fm = fraction of compounds shelved as potential mutagens, and
T = annual cost of bioassays.

An estimate of the annual R&D outlays by drug and chemical firms is contained in the National Science Foundation publication *Research and Development in Industry, 1979*. The figure is $1.99 billion in 1979, or about $3.3 billion in 1982 dollars. Based on an informal survey of a number of firms, 5 percent appears to be a fair estimate for the fraction of compounds found to be potential mutagens. Dr. Ames estimated that over 3000 laboratories worldwide use his test routinely, resulting in an estimate of $35 million to the annual cost of bioassays. This results in an estimated annual cost savings of some $140-million/year in 1982 dollars.

Use of these low-cost tests to screen existing products that have never been examined for mutagenic potential represents a potential future benefit. Thousands of man-made compounds are currently in use. To date EPA has inventoried under the Toxic Substances Control Act over 60,000 such compounds that have never been tested for carcinogenic potential. Because the present capacity for animal testing in the United States is limited to a few hundred compounds per year, short-term cell bioassays are the only feasible means of screening these substances.

Analyzing Complex Mixtures for Toxic Agents By the early 1960s, existing instruments were reaching limits that would adversely affect important areas of health and environmental research and progress in increasing industrial safety. Two such limits were the inability to determine the elemental composition of nonradioactive mixtures suspected of containing trace amounts of toxic materials and the inability to ascertain the isotopic composition of complex mixtures of radioactive elements such as those being encountered in nuclear reactors and laboratory analysis. Solutions to both of these problems emerged from the OHER research program. The first solution, a semiconductor X-ray spectrometer, has been widely applied to detect pollutants in the environment, identify unknown materials in the scrap metal and metal manufacturing industries, and to locate sites for examination by electron microscopes. The second solution, a high-resolution gamma-ray spectrometer, is commonly used for identifying the elements in the cooling water of nuclear power plants that cause radioactivity, logging oil wells, studying distant planets, and analyzing laboratory samples.

Semiconductor X-ray Spectrometer (SXRS) This instrument is widely used in industry, medicine, and scientific research to determine the elemental composition of nonradioactive materials. The SXRS is a member of the family of X-ray fluorescence spectrometers and is also known as the energy-dispersive X-ray spectrometer.

The SXRS has three primary components: a radiation source, a semiconductor detector, and a processor. The radiation source can be any material or device that emits X-rays; an isotope of iron that naturally emits X-rays is frequently used. X-rays from the source are directed at the sample to be analyzed, causing the sample to emit other X-rays. The semiconductor detector is made of silicon with lithium added (lithium drifted into it) to obtain the desired detection capability. When X-rays enter the detector, the resulting interaction or ionization produces current pulses that are directly proportional to the energy of the X-rays from the sample. The processor, an electronic logic circuit, counts the number of pulses and records the pattern of X-rays, the distribution of measured energies. Because each element emits a unique pattern of X-rays, the elemental composition of the sample is identified. The typical output produced by the processor is a table showing the percentage composition of the sample.

History X-ray fluorescence spectrometers have been in use since the 1930's, when the wavelength-dispersive X-ray fluorescence (WDXRF) spectrometer was developed. However, the WDXRF spectrometer has limited resolution and can only analyze one element at a time. It is, thus, a very costly method, particularly when a large number of elements must be analyzed. Older methods of chemical analysis, particularly wet chemistry, which is very slow and destructive, were still predominant in 1960.

Research on alternative methods was undertaken on a large scale in the 1950's in the United States and other countries. The electronic properties of silicon and germanium were discovered during this period, and the first silicon detector was developed in 1960. The lithium-drifting process, which permitted construction of detectors thick enough to totally absorb the X-rays, was developed in 1960 and 1961.

These first semiconductor detectors provided improved resolution to distinguish elements, but the associated electronic processors were too poor to maintain the resolution. From 1963 to 1969, research to improve the associated electronics was undertaken. By 1965 a high-resolution SXRS was developed. During this period, improvements in the detectors and further development of the entire X-ray detector system also took place. New applications were explored as scientists realized that the SXRS could potentially be used in industry and medicine in addition to laboratory analysis. Commercialization of the SXRS began in 1965, primarily to university, Government, and corporate laboratories. Between 1970 and 1973, trace-element analysis improvements were made at

Lawrence Berkeley Laboratory (LBL). Improvements were also made in the speed of analysis such that a complete analysis of a typical sample now took less than 1 minute.

Approximately 8300 commercially manufactured SXRS units are presently in use in the United States. Of these, 2500 units are stand-alone analysis systems that include the radiation source, detector, and processor. The users of these systems fall into three categories: (1) industry; (2) commercial laboratories; and (3) Government, academic, and medical laboratories. The remaining 5800 SXRS units are attached to scanning electron microscopes.

About 350 of the 2500 stand-alone SXRS systems are used in the scrap metal, steel and metal manufacturing, and durable manufacturing industries. All of these units are located in the production area and are used as part of the production process. Approximately 1000 SXRS systems are used in commercial laboratories where they are typically one of many elemental analysis instruments used away from the actual production process.

The remaining 1150 of the stand-alone systems are used both for research and analysis of trace elements in patient specimens in National, university, and hospital laboratories.

The SXRSs attached to scanning electron microscopes assist the microscope in plotting a "map" of a surface; the elemental composition of each small area is determined separately, and the peaks and valleys are identified. These instruments are widely used in both commercial and Government/university/medical laboratories. They are used frequently in quality control of ball bearings, airplane bodies, and machine parts, as well as in new materials research.

Eight factors are responsible for the large number of SXRS units in use and the wide variety of uses.

1. The SXRS analyzes all elements of a given sample simultaneously, thereby providing a complete elemental composition of the sample.
2. The SXRS's measurement accuracy is tenths of parts per million.
3. The SXRS provides information rapidly, typically in 10 to 30 seconds.
4. The SXRS is nondestructive.
5. The SXRS is flexible and can be programmed to analyze single elements in less than 5 seconds.
6. The SXRS can use portable detector attachments, and even the non-portable units require little floor space.
7. The SXRS system requires little additional maintenance.
8. The SXRS does not usually require skilled personnel.

Benefits The benefits of SXRS development are twofold: (1) reduction in the cost of analyzing materials compared with other elemental analysis techniques and (2) availability of information not otherwise obtainable.

The cost savings accumulated through 1982 by industrial and commercial users provide some indication of the benefits of SXRS development. SXRS users were contacted and asked to estimate the 1982 cost savings that could be attributed to the SXRS. Average annual savings for five user groups—scrap, steel/metals, manufacturing, commercial (nonresearch), and commercial (R&D)—were estimated to total $88 million/year in 1982.

High-resolution Gamma-ray Spectrometry Gamma-ray spectrometry is a method of detecting, characterizing, and monitoring gamma radiation. The development of lithium-drifted germanium [Ge(Li)] and high-purity germanium [Ge(HP)] solid-state semiconductor detectors and improvements in the associated electronics have revolutionized the field of gamma-ray spectrometry, particularly with respect to energy applications.

As a result of their much higher resolution (the ability to distinguish between gamma rays of different energies), germanium spectrometers have replaced other types of gamma-ray spectrometers in many uses. They are now commonly used in nuclear power plants, industry, and research institutions for identifying the elements in reactor cooling waters that cause radioactivity, logging oil wells, studying distant planets, and analyzing biological and laboratory samples.

History Until about 1970 the device most frequently used for gamma-ray spectrometry was the scintillation spectrometer. The most widely developed scintillator is a sodium iodide crystal that emits light when penetrated by gamma rays. The light is collected and converted to an electrical signal by a photomultiplier tube. The scintillation spectrometer is an efficient detector of gamma rays. However, the resolution of the scintillator is not fine enough to distinguish between isotopes emitting gamma rays of very similar energies. The need for a spectrometer with higher resolution in physical and biological basic research was the primary impetus for germanium spectrometer development.

The first germanium gamma-ray detector was developed in 1962 as a result of Federal (non-OHER), private, and foreign-sponsored research. The original instrument was inferior to the scintillator in both resolution and efficiency. Improved resolution was achieved in 1963 through OHER-sponsored research at LBL, BNL, and ORNL.

By 1971 the results of OHER research were twofold. First, the process of drifting the germanium crystal with lithium was improved, which considerably enhanced the resolution of the detector. Second, the associated signal processing system was developed further so that the resolution of the detector was not degraded by the processor. During this period, the Ge(Li) detector surpassed the scintillator in resolution, and its use in research applications became widespread. These detectors, however, had to be manufactured and operated at very low (cryogenic) temperatures.

Research on the development of Ge(HP) detectors was initiated at LBL and General Electric (GE). The first high-purity germanium detectors were sold by GE in 1974. These detectors still needed to be cooled during operation but not during manufacture and storage. Manufacturing and operating costs fell as a result.

The ability to work with the germanium at room temperature also permitted the construction of multidetector systems. By connecting as many as ten detectors to a single processing unit, the efficiency of the germanium detector array can be increased without sacrificing resolution. These multidetector arrays are ideally suited to situations such as medical research and power plant environmental monitoring. Between 1975 and 1982, OHER funded development of these multidetector arrays at LBL.

Benefits Gamma-ray spectrometers are used primarily for gamma radiation monitoring and elemental analysis of radioactive or neutron-activated materials. Accordingly, gamma-ray spectrometer users fall into four main categories:

1. Nuclear power plants use gamma-ray spectrometers to monitor the content of gas and liquid effluents and the environment of the plant and to measure the condition of the reactor fuel elements.
2. Laboratories (National, university, and commercial) use spectrometers to monitor the environmental conditions of the laboratory and to perform ele-

mental analyses.

3. Resource exploration companies use spectrometers in serial and ground surveillance and mapping and in wellhole logging.
4. Environmental monitoring organizations (such as state and local environmental protection agencies) use spectrometers to monitor levels of radiation being emitted into the environment.

For users of gamma-ray detectors and spectrometers who require a high level of resolution, the only alternative in these applications is time-consuming chemical separations. The real choice to be made by users, therefore, regards the degree of resolution required. None of the competing detectors has the resolving power of a Ge(Li) or Ge(HP) detector.

Discussions with representatives of gamma-ray spectrometer systems and detectors indicated that the market is approximately $7 to $8 million annually. One major manufacturer offered a distribution of units by type of user:

User	Percent of units
Public utility	<10
Laboratories	75
Resource exploration	5
Environmental monitoring	10

The major manufacturers of Ge(Li) and Ge(HP) detectors are Canberra Industries, EG&G Ortec, and Princeton-Gamma Tech Inc.

The use of germanium detectors is most often justified by the need for fast, high-resolution measurements. Fairly short scan times are reported for Ge(Li) detectors, ranging from 100 to 1000 seconds. The time for radiochemical analysis to perform the same analyses ranges from one-half day to several days.

Cost savings associated with using germanium detectors were estimated based on discussions with the staff of approximately 20 utilities operating power reactors. Based on this survey, the annual cost saving in 1982 was estimated as $21.2 million. Past savings were estimated as $230 million (present value). Almost all of these benefits represent cost savings associated with measurements for which the alternative is radiochemistry.

It appears that other important, but difficult to quantify, benefits are being realized. For example, much of the scientific work in nuclear physics could not be performed without the germanium detector. Interestingly, a number of isotopes have been discovered by scientists using the Ge(Li) detector. The device is currently being used to determine whether the neutrino has mass. Also, the germanium spectrometer is now a primary method of gamma-ray spectrometry in astronomy.

Industrial Hygiene Monitors The expertise and methods in measurement sciences accumulated in the nuclear energy program served the Nation well in the 1970's when complex chemical mixtures became an area of vital concern in exploring the potential of synthetic fuels from coal. Lapel and pocket dosimeters for monitoring exposure to polycyclic aromatic hydrocarbons [(PAHs), known carcinogens] were developed to meet the needs of industrial hygiene. Sensitive instruments to measure skin contamination and spill spotters able to measure previously undetectable amounts of chemical contamination also emerged from the OHER Program. In addition to monitoring devices, scientific procedures such as biodirected chemical analysis were developed to measure the carcinogenic and mutagenic properties of complex mixtures of chemicals derived from coal liquefaction and gasification.

As part of the efforts aimed at detecting toxic chemicals, a survey of instrumentation for environmental monitoring was published, and an instrument for monitoring concentrations of PAH compounds, a hydrogen fluoride monitor, and a portable elemental survey meter were developed. The three monitors are in the prototype stage of development. A handbook *The Survey of Instrumentation* for Environmental Monitoring* has been in use for several years and will soon be issued by a private publisher. This handbook provides baseline reference information to assist researchers and industrial hygienists in selecting the appropriate method for measuring energy-related toxins.

Instrumentation under development will provide simple and passive methods of monitoring worker exposure to hydrogen fluoride, more sensitive measurement of worker and skin contamination and work area surface contamination by PAHs, and a nondestructive method of measuring formaldehyde emissions. These monitoring techniques address the critical health-related measurement needs associated with these toxic chemicals.

History The Industrial Hygiene Measurement Science and Instrumentation Program was initiated to develop new or improved measurement tools and techniques to address a broad range of health protection problems. Since its inception in the late 1940's, the program has focused on concerns associated with chemical toxins related to atomic energy defense activities.

With the creation of ERDA, then DOE, and with broader missions to cover all energy and conservation measures, increased emphasis has been placed on chemicals related to energy development. These include PAHs, which are inherent in synthetic fuel production; hydrogen fluoride, an important chemical in DOE uranium enrichment activities; trace elements, which include respiratory and inhalable toxic metal particulates and vapors; and formaldehyde, a potential carcinogen found in materials used for building energy conservation.

Benefits The major benefit of this measurement science and instrumentation research is improved information aimed at protecting the health of industrial workers and the public. Advanced instruments are used to develop new and improved data to identify health hazards. The use of overly conservative and expensive health protection measures or, conversely, underestimation of the risks of human exposure to chemical pollutants is thereby avoided.

1. *The survey of instrumentation for environmental monitoring.* This handbook was compiled by LBL to assist users in efficiently selecting appropriate instrumentation. It is based on responses by over 4000 users, including state and Federal environmental agencies, analytical laboratories, instrument manufacturers, and technical libraries. Separate volumes have been published on air, water, and radiation monitoring methods, with each volume organized by pollutant. There are three major sections under each pollutant. The first section discusses the reasons for monitoring the properties of the pollutant, information on health and environmental effects, and regulatory standards and requirements. The second section describes, compares, and contrasts the principles used by the commercially available instrumentation methods. The third section presents a one-page summary for each of the commercially available instruments. The water volume, with a current circulation of 4000 copies, has been purchased by most of the water pollution control agencies in the United States. The volumes on radiation and water have been published and

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*LBL, Environmental Instrumentation Group, Vol. 1(4), 1972–1980, John Wiley and Sons.

marketed by John Wiley and Sons.

2. *Monitoring of PAH compounds.* The Spill Spotter and the passive vapor dosimeter provide the capability to monitor routinely and cost-effectively PAHs in the workplace. The Spill Spotter is a device that illuminates PAHs with light of a specific color, causing them to fluoresce. The instrument then measures the fluorescent light emitted. The instrument is a hand-held optics unit similar in size to a small video camera and is connected to a small electronics module. Easily changed excitation and emission filters provide selective detection of classes of organic compounds. This instrument also permits discrimination between organic and inorganic compounds. The Spill Spotter is simpler and safer to use and provides quantitative results comparable to existing methods. Its development was recognized by an IR-100 Award in 1980.

   The vapor dosimeter is a passive air sampler that can be worn conveniently by the worker as a lapel badge or used as an area monitor. It is a unique device designed to measure the overall exposure to PAH compounds with three or more rings and can measure dosages as low as parts per billion. The dosage is read by placing the badge in an optical analyzer using the room temperature phosphorescence technique. The passive vapor dosimeter is faster, simpler to use, and less expensive than existing instrumentation. An IR-100 Award in 1981 recognized its invention.
3. *Hydrogen fluoride passive dosimeter.* A hydrogen fluoride passive dosimeter was developed by ABCOR, Inc., under contract to DOE. This monitor is used for industrial health monitoring at the ABCOR enrichment facility. Uranium hexafluoride breaks down into uranyl fluoride and hydrogen fluoride when it comes into contact with water vapor in the air. This dosimeter detects the hydrogen fluoride reaction product and has advantages over the existing methods for measuring hydrogen fluoride. It is small and simpler to use, and it can be worn on the lapel. In addition, it requires no pumps, impingers, sampling tubes, or calibration. The collection element can be analyzed quickly and easily with a fluoride-selective ion electrode. Further, it can be used either as a personal or an area monitor.
4. *Portable elemental survey meter.* The portable elemental survey meter was developed under a DOE contract by Columbia Scientific Instruments for rapid, on-the-spot, elemental analysis of air particulates collected on filters (including respirable and inhalable particulates) and vapors collected on membranes by chemical adsorption. It was designed to meet the accuracy requirements for sampling in the workplace. The sampling method is nondestructive and can detect 23 elements. The survey meter provides immediate elemental analysis of air particulates and vapors present in the work environment; the alternative is to send the samples to an analytical laboratory. The meter can be used for rapid on-site checking of air contaminants in the case of accidental releases, as well as for routine monitoring purposes. For example, it can be used in the metallurgical and energy production industry to monitor welding fumes (which contain toxic metallic elements) or to measure air contaminants found in other workplace environments. The device is portable and is enclosed in a small compact carrying case. It uses a microprocessor-based, energy-dispersive, X-ray fluorescence technique to measure sequentially the concentrations of

selected sample elements whose calibration parameters are stored in memory. Analysis time is on the order of 100 seconds/element.

Predicting Pollution Pathways in the Atmosphere Although great improvements have been made in our understanding of the processes that move pollutants through the atmosphere and deposit them in aquatic or terrestrial ecosystems, an even greater understanding is necessary to solve the problems presented by acid rain and the change in the heat budget of the earth caused by carbon dioxide increases. A step in this direction has been made by the production of stable, nontoxic tracer gas that can be released from source areas and detected at great distances.

Understanding and predicting pollutant transport are important because it is a principal means by which health effects might be produced in the public by an emerging technology. The OHER research program pioneered the mathematical modeling, or prediction, of pollutant behavior in the atmosphere because of the early responsibility for understanding the possible effects of radioactive contamination. Models of the movement of materials through and chemicals reaction in the air and soil are crucial to rational decisions related to citings of toxic waste dumps and to optimal decisions on mitigation to correct past mistakes. However, the validity of models and predictions must be tested, and OHER has also supported the development of the necessary tools for verification.

Although gas tracers have provided valuable information of this kind, it is also known that pollutant gases often interact with minute particle clouds (aerosols) from which the particles may be deposited on the ground or become resuspended in air. Pollutants themselves may even originate as aerosols. New instruments were needed to understand the transport and cycling of particles in streams, lakes, oceans, and the atmosphere. This need was met by developing aerosol and particle analyzers for both atmospheric and aquatic studies. Today these analyzers form a vital part of the Nation's ongoing research into the effects of airborne chemical pollutants, notably acid rain.

The major benefit of this research has been a sounder understanding of the relationships between pollutant releases and their concentrations in the human environment. Information of this nature is essential to regulation of pollutants in the general interest and for sound industrial planning.

Atmospheric Tracers Several nonradioactive, chemically inert systems have been developed to trace the dispersion of materials released into the atmosphere. These include tracers, samplers, and extremely sensitive analyzers that can detect materials at concentrations as low as 2 parts per quadrillion (10^{-15}). Such systems can be used to trace dispersions at ranges of over 100 kilometers.

Increased concern over the regional and international aspects of air pollution has created a need for reliable model calculations of concentrations as far as 1000 kilometers from pollutant sources. Experimental verification of these calculations, as well as environmental assessments based on model simulations, is essential to establish the credibility of models of dispersion processes. One way to verify the models is to trace the movement of actual materials in the atmosphere. This requires cost-effective, nonreactive and nondepositing tracers for local (less than 100 kilometers), intermediate (100 to 1000 kilometers), and long-range (greater than 1000 kilometers) dispersion of pollutants. The tracers must also be nonradioactive, nontoxic, and inexpensive and have low natural background to perform adequately.

Three sampling systems for perfluorocarbons have been developed. The BNL automatic tracer sampler was designed to be easily portable (15 pounds), automatic, and reliable. Each sampler can take a sequence of 23 samples of air. The start/stop time, flow rate, and total volume through the sampling tubes can be controlled. Each sampling tube contains 150 milligrams of Ambersorb, which traps all of the perfluorocarbon. The tracer is then recovered by thermal desorption from the sample tubes and separated by gas chromatography. An electron-capture detector provides measurement accuracy of 10 to 20 percent at concentrations as low as 2 parts per quadrillion (background concentration) with an 8-liter capacity air sample.

A second sampler, the prototype called the "dual-trap sampler," combines both sampling and analysis. Using two sampling tubes, it simultaneously traps a new sample as it analyzes the previous sample. This device can provide analysis of one air sample containing perfluorocarbon tracers every 5 minutes. It can detect perfluorocarbon tracers at their ambient levels with 15 percent accuracy essentially in real time.

The third prototype sampler is a real-time continuous monitor intended primarily for use in aircraft sampling. Air is drawn through a catalytic reactor that removes the oxygen and other electron absorbers, leaving the perfluorocarbons and nitrogen in the remaining air. This air is passed directly to an electron-capture detector that provides continuous readout of perfluorocarbon concentration with only a 3-second delay. When completed, this sampler should yield accuracies of 0.1 parts/trillion in measuring perfluorocarbon traces.

History In the early 1970's, the only available atmospheric tracer with acceptable physical properties was SF_6. The difficulty in measuring trace amounts of SF_6 against natural and man-made backgrounds limited its usefulness to a range of about 150 kilometers. Recognizing the need for longer-range tracers, OHER initiated research into two tracer types:

1. *Perfluorocarbon tracer.* Investigations reported by 1974 indicated that a perfluorocarbon tracer system could be developed that would be ideal for long-range dispersion studies. The NOAA Air Resources Laboratories contracted with Lovelock to develop the three different samplers as the first step in the development of the new tracer system. Prototype instruments were delivered by Lovelock in 1976. Since then the laboratory has been working closely with DOE's Environmental Measurements Laboratory (EML) and BNL in a cooperative effort to develop a practical perfluorocarbon system.
2. *Heavy methane tracer.* Following the observation that air contained an insignificant number of atoms with an atomic mass of 21, Los Alamos initiated work in 1973 to develop a tracer with that atomic mass by synthesizing carbon-13 and deuterium into heavy methane, CD_4. Both carbon-13 and deuterium are available from other Los Alamos programs. Concurrently, scintillation techniques for detecting single ions using mass spectrometry were being developed at the Atomic Weapons Research Establishment (AWRE), United Kingdom. After the initial tests of heavy methane tracers at AWRE were completed, OHER funded the development of a mass spectrometer analytical capability at Los Alamos to measure the

tracer levels in ecological samples.

Several field experiments have been conducted to test the perfluorocarbon and heavy methane tracer systems. The most important of these were two demonstrations conducted in July 1980. In the first demonstration, SF_6 perfluorocarbons and heavy methane tracers were released and sampled at distances of 100 and 600 kilometers. The second trial used only perfluorocarbons and SF_6 with sampling only at 100 kilometers.

The key issue to be resolved by the experiments was whether the tracers and the analysis systems were similar; that is, if equal amounts of the two perfluorocarbons were released, would equal amounts be detected at every location? Even more crucial were the direct comparisons of different tracers, such as the perfluorocarbons and the heavy methanes.

The experiments proved that the perfluorocarbon and methane tracers behaved the same in the atmosphere, faithfully following the air motions and remaining in the air streams out to 600 kilometers from the source. Considering that the heavy methane and perfluorocarbon determinations are conducted by totally different analysis techniques (mass spectrometry for the methane and gas chromatography followed by electron-capture detection for the perfluorocarbons), these results inspired confidence in both tracer systems.

Benefits Atmospheric tracers are a recent development that may find applications in several research areas. These tracers allow the validation of computerized models to describe atmospheric transport and dispersion, as well as the investigation of fundamental aspects of dispersion or dynamic meteorology not accessible by other means.

These tracers will find applications in facility siting and empirical studies of specific situations where there is no adequate model of the dispersion of emissions or when existing models are inadequate because of the complexity of the terrain. For example, in a recent DOE study of drainage winds in complex terrain, the tracers were used to determine the capability of existing wind patterns to remove pollutants vented from geothermal wells.

Aerosol Instrumentation, Dry Deposition, and Resuspension In an effort to predict the fallout of minute particles of radioactive debris from weapons tests, research was undertaken in the science and technology of aerosols. Subjects studied include particle behavior in the stratospheric air, tropospheric interactions with rain and snow, and deposition in lungs from inhalation.

Dry deposition is the process by which particles and gases are transferred to the earth's surface from the air. Research into dry deposition has made possible the development of predictive models that relate deposition velocity to particle diameter. Although these models still contain considerable predictive error, the results are typically an order-of-magnitude improvement over earlier practice.

Resuspension is the process by which particles and gases become reintroduced into the air from the earth's surface. Research into particle resuspension has made possible the development of models to predict resuspension rates, which are used as boundary conditions in air transport models needed to reliably predict what will occur downwind.

History Research on dry deposition stems from attempts in the 1960s to measure worldwide fallout of radioactive debris from weapons testing. Dry deposition on grazing lands was of particular concern because it introduced radioiodine into the food chain. Researchers identified the phenomenon and developed a now widely used system that collects dry and wet deposition separately. The early monitoring efforts resulted in a body of data but also made clear the inadequate understanding of the underlying physics. The results of OHER-supported research into aerosol phenomena was combined in 1973 with other advances in aerosol research and with the emerging electronics technology to produce a new electrical aerosol analyzer for surface-level use. Compared with the preceding electrical analyzer, the prototype achieved an approximate sixfold reduction in size and weight. Recognizing its potential, TSI, Inc., an instrument manufacturer, completed the design and engineered a reliable electronics package for the unit. After its market introduction in 1974, the unit quickly became the standard method for measuring the number and size of submicron-sized particles or drops in aerosols.

Benefits Over 200 units of the electrical aerosol-size analyzer have been sold since its introduction in 1974; nearly one-half of these sales have been to overseas customers. TSI supplied the following approximate domestic sales by category:

Number of units	Applications
50–60	Air pollution monitoring and research
12–15	Diesel combustion research and health effects research
10–12	Military research on smokes, obscurants, and aircraft condensation trail suppression

Other applications include commercial smoke detector development and calibration, research on commercial air filters and demisters, semiconductor clean rooms, and particle-size control of carbon black in tire manufacturing.

A number of health, safety, military, and industrial benefits are associated with the use of electrical aerosol-size analyzers. Air pollution monitoring and research benefits include accuracy in quantifying airborne pollutants, identifying particles small enough to be respirable, and improving the ability to enforce emission regulations for point sources. Benefits arising from diesel combustion and health-effects research include the ability to monitor more precisely the diesel combustion exhaust and to evaluate more effectively the effect of design changes on exhaust products. Research on smokes, obscurants, and aircraft condensation trail suppression enhances the survivability of military personnel and equipment. Industrial benefits include clean-room monitoring, leading to a lower rejection rate of electronic components and assemblies; particle-size control of carbon black used in tire manufacturing, resulting in greater tire treadwear; and miscellaneous applications, such as smoke detector development and calibration, information on the effects of pollutants on plant growth, and development of commercial air-cleaning filters and demisters.

A sound understanding of the complex relationships between pollutant emissions and pollutant concentrations in the environment is essential for promulgating sound environmental policy. In this regard, research on dry deposition and resuspension can benefit society in one of two ways: by providing basic data needed to demonstrate that human and environmental exposures to harmful aerosols are less than currently believed or by demonstrating that the threats are greater than currently believed. In the former case, society can benefit from this information by devoting fewer of its scarce resources to emission controls, and in the latter case, it benefits by taking actions to reduce emissions.

An additional benefit from research on resuspension relates to windblown soil erosion. The physical processes of resuspension and soil erosion are essentially the same. Hence, the results of research on resuspension can be applied directly to the study and prevention of windblown soil erosion.

Identification and Evaluation of Environmental Effects

The concerns resulting from energy production and use have ranged from disturbance of natural systems by mining, deforestation, and drainage to offshore drilling, toxic waste disposal, thermal discharges, and the contamination or pollution of sources of food. Research initiated to gain an understanding of the effects of fallout from weapons tests, potential discharges from weapons production facilities, and pathways radioactive materials and other energy-related materials follow in moving from their source to the size of potential danger has been expanded to encompass pathways of substances through the food chain, underground migration of substances, as well as aspects of radioecology, geology, and many other fields.

Riverine Ecology "Riverine Ecology" is the title given to a group of studies and models developed to understand and describe the environmental impact resulting from industrial heating of river water.

History Beginning in the late 1940s, the environmental impacts of once-through cooling of reactors built for the United States nuclear weapons program at Savannah River and Hanford were the object of research on riverine ecology by the AEC. Later, environmental impacts resulting from once-through cooling of power reactors prompted a major research program at Oak Ridge on riverine ecology. The program focused on power reactors in an effort to anticipate problems the nuclear industry might face in complying with the National Environmental Policy Act and other environmental laws. The problem of heating river waters is primarily nonradiological in nature and, thus, also germane to coal-fired plants, pumped-storage reservoirs, and other operations that have the potential to cause large-scale changes in river conditions.

By reviewing and analyzing worldwide experience and by conducting laboratory experiments, researchers were able to compile a data base on aquatic ecology impacts and establish criteria for altering water quality. From these data was developed a set of models of fish population dynamics, entrainment and impingment at plant intakes and discharges, and transport of water and entrained fish and larvae. The focus of this research was on the striped bass population of the Hudson River, site of the Indian Point Unit 2 nuclear plant. Later, the scope of the program was expanded, both in depth (to include more detailed studies of factors governing entrainment and impingement) and breadth (to include studies of other fish populations).

Benefits This basic research on riverine ecology led to the development of a body of knowledge that could be applied to a variety of problems arising in the design and construction of large electric power plants. The information was used specifically to evaluate the need for cooling towers planned for several power plants on the Hudson River.

Riverine ecology research was instrumental in the negotiated resolution of the longstanding dispute over the impacts of power plants at Indian Point (nuclear) and Bowline and Roseton (oil-fired) on the ecology of the Hudson River. At the time of the settlement (December 1980), EPA had entered its fifth year of administrative deliberations over whether the plants would be required to be retrofitted with cooling towers. Previous studies had alleged that the plant's emission of warm water and its huge withdrawals of river water for once-through cooling would kill mature fish (through collision or impingement) and would draw in and injure or destroy (entrain) juveniles, larvae, and eggs and, thus, contribute to a serious depletion of the Hudson River population of striped bass.

The use of the models developed in the OHER research indicated that the impacts on striped bass were smaller than alleged but determinable. With the boundaries of the dispute settled, the parties were able to reach a compromise solution that served both their plan and the public interest. This is, perhaps, the major significance of the Hudson River case. Following its settlement, Russell Train, former EPA Administrator and mediator for the Hudson River case, stated, "the settlement demonstrates that acceptable accommodations can be reached which effectively balance the environmental and energy needs of the Nation . . . [through] mediation and negotiation, rather than by sole reliance on the more traditional adversarial legal procedures."

Ecology of the Continental Shelf The continental shelf, which accounts for less than 10 percent of the total ocean surface area, produces most of our seafood. This shallow perimeter of water off our coast receives nearly all of the contaminants that wash off the land and flow downstream. Because it is the more productive, the coastal area is more susceptible to damage from pollution than are deeper parts of the ocean. Research on the continental shelf was initiated to determine the environmental impact of effluents from nuclear and fossil power plants on coastal areas and also to predict the effect of energy discharges over the coastal zone.

The sea, like the lowest region of the earth's atmosphere near the surface, is self-cleansing. Thus, it has a carrying capacity for contaminants. We need to know this carrying capacity to be sure that the sea is not used beyond its capabilities.

History The continental shelf program evolved from work that grew out of concern about nuclear fallout from weapons testing in the Pacific. Work began in the deep ocean, following the movement of the radionuclides from Eniwetok and Bikini in the Kuroshio Current toward Alaska. It soon became apparent, however, that the primary route of radioactivity to humans from the ocean was through seafood. Fallout on land was washed into the coastal zone, raising interest in the natural processes that move contaminants in this area.

The first integrated program dedicated to coastal transport was begun by DOE in 1975, using oceanographers from Skidaway Institute, the University of Georgia, the University of Miami, and North Carolina State University. The study began with an investigation of coastal currents that move dissolved contaminants, specifically the Gulf Stream that sends tongues of water twisting into the coastal zone, causing quantities of contaminant-laden water to move offshore. The scientists then moved inshore to study the mechanism driving freshwater runoff from rivers through the "dam" of saltwater offshore, carrying contaminated coastal water out to the deep ocean. Their research has shown that the coastal zone is regularly flushed and the buildup of contaminants is reduced periodically.

In the Northeast, oceanographers from the Woods Hole Oceanographic Institution, Yale University, the University of California at Los Angeles, North Carolina State University, Columbia University, and Brookhaven National Laboratory studied, and continue to study, the movement of natural particles and the manner in which they attract contaminants. The importance of this research was highlighted by the earlier discovery, in which DOE played an important role, that many, indeed most, pollutants tend to attach themselves to particles that gradually fall to the bottom of the sea. Also, since many of the particles involved are photoplankton cells rich in carbon, this line of research is important in understanding how carbon dioxide is being removed from the atmosphere and stored as deposits of organic carbon in the ocean at the edge of the continental shelf.

Present research continues to study the processes that move contaminants in the coastal zone. The scope of studies has been expanded to include the Pacific Ocean off California. Special interest is in those processes that transport materials across the shelf and into deeper waters of the open ocean, where their direct impact with humans and natural coastal systems is minimized.

Benefits This continental-shelf dynamics program benefits many users, including:

- *DOE*. DOE is responsible for cleaning up several sites containing materials associated with earlier nuclear activities through the Formerly Utilized Sites Remedial Action Program. Data developed by the continental-shelf dynamics program are a key element in deciding whether sea disposal is safe. The program has also provided models to predict the fate of spilled materials, such as the oil from the Argo-Merchant. The information developed is also used by other agencies involved in modeling oil spills. Moreover, the modeling capability provides crucial information required to support the leasing of offshore tracts for oil development.
- *State and Federal regulatory agencies and utilities.* In Washington and Oregon, the program identified sites where industrial activities might harm the razor clam fisheries. Work at the Scripps Institution of Oceanography helped establish the chlorine release standard for the California coast. Studies at the University of Washington have shown that mercury is rapidly removed in coastal waters and could, therefore, be safely released at higher levels than previously anticipated. In the past, floatables in municipal wastes drifted onto the beaches of Long Island, closing more than 100 kilometers of beaches and causing an estimated $20-million (1976) loss in the tourist and related industries. The coastal-shelf model predicted the path of the wastes and showed that dumping farther off-shore or storing wastes for later dumping during favorable conditions could help avoid these damages.
- *Fishing Industry.* Based on a consideration of fronts, temperature, and upwelling, the coastal-shelf dynamics work helps determine where the fish are located. The impetus for fishery development was provided by a NOAA Sea Grant, and the information was provided by the coastal-shelf dynamics program. Dockside values of fin fish which landed in Georgia rose from less than $38,000/year from 1969 to 1975 to over $230,000/year from 1976 to 1979. The program has similarly benefited fin fisheries in South Carolina.

In 1976 there was a major kill of shellfish along the New Jersey coast with estimated damages of $50 million. The coastal-dynamics program investigators identified the conditions and implemented an early-warning system in case similar conditions recur. Fisheries experts estimate this knowledge would enable them to save one-half of the shellfish. It is estimated that the peculiar oceanic conditions that lead to fish kills would occur about one year in ten.

Tracing Pathways of Nuclear Wastes in the Life Cycle Small amounts of transuranic elements produced by nuclear energy activities may move through the environment and back to humans or other biological organisms. (Transuranic elements are those with atomic numbers greater than uranium; they are radioactive and can be toxic to humans.)

Hundreds of tons of transuranio elements, mostly plutonium, have been produced since World War II as a part of nuclear weapons production. Small losses to the environment from processing have occurred. Such losses have been studied at the Savannah River Laboratory and the Savannah River Ecology Laboratory. Plutonium emitted from a nuclear fuel separations plant is followed through the aquatic and terrestrial environments, and its dose to humans from ingestion is assessed.

Plutonium particles from the Savannah River nuclear fuel separations plant attach to dust particles. Concentrations of these particles in the air provide potential annual doses of less than 1 percent of the natural background at the plant boundary. Wheat, corn, soybeans, root crops, and tobacco grown in plutonium—containing soil—had the most plutonium on the surfaces, not in the edible part, of the plant. The potential dose from plutonium to humans eating these crops after more than 20 years of Savannah River operation is less than from naturally occurring radioactive potassium-40 in the same soil.

Measurements in sediments, biota, and water in estuarine systems near the Savannah River indicate that plutonium concentrations in this watershed are not different from those of watersheds with no nuclear facilities, even though the Savannah River is near one of the highest concentrations of nuclear facilities in the United States.

The results of all transuranic cycling research up to 1980 have been compiled in a book entitled *Transuranic Elements in the Environment: A Summary of Environmental Research on Transuranium Radionuclides Funded by the United States Department of Energy Through Calendar Year 1979*, [ed. by Wayne C. Hanson (DOE Technical Information Center), DOE/TIC-22800, 746p, 1980]. These research results, plus later scientific papers, form a valuable data base on transuranic cycling in the environment. Perhaps equally important is the evolution of a group of scientists who can answer questions about transuranic elements that arise from civilian and military applications of nuclear technology.

History Before 1973 environmental research into the behavior of the transuranium elements was conducted on an ad hoc basis, usually in response to an accident, such as the loss of nuclear material in military aircraft accidents, or to "hot spots" found in the environment, such as the discovery of plutonium concentrations that exceeded fallout levels (e.g., near the Nevada Test Site). Short studies were usually undertaken to describe the distribution of plutonium and assess the health hazard at the particular site. This information provided some basis for generalized observations about environmental movement, but most of the in-depth studies were only applicable to soils of high pH.

No concerted studies had been made of transuranic element movement through aquatic food chains or the marine environment. Early studies did not address whether biological modification of the transuranium elements might increase their mobilization in the environment, with more movement to humans. To remedy these deficiencies, OHER initiated basic research activities covering all aspects of environmental transport from soil processes to ecosystem cycling.

Benefits The major benefits of the information from OHER's transuranic environmental cycling research are utilized by:

1. *Nuclear Standard-setting Agencies, both National and International.* The results of research on transuranic cycling represent virtually the sole source of such data which is vital to standards writing bodies such as the National Council on Radiation Protection for the United States, the National Radiation Protection Board for the United Kingdom, the International Atomic Energy Authority, and the International Commission on Radiation Protection.
2. *Defendants in Personal Injury Litigation.* The United States and its contractors have been, and are being, sued by plaintiffs who claim damage caused by transuranic elements and other radioactive substances to which the plaintiffs were allegedly exposed. The body of scientific knowledge on transuranic elements developed by OHER-sponsored research is being used in such litigation. The damages sought in these suits can be extremely large. In one such case, the punitive damages sought were $4 billion.
3. *Hazardous Waste Managers.* The mathematical models developed and validated for chemicals containing transuranic elements can be applied to similar materials in the environment. Specifically, the modeling of surface erosion, surface water transport, and sediment transport in the canyons near Los Alamos has helped to determine remedial actions needed to deal with other forms of contamination in Los Alamos County.
4. *Future Plutonium Facility Design and Operation.* The transuranic cycling research at the Savannah River Laboratory and the Savannah River Ecology Laboratory has verified that technology exists for containing plutonium in operating nuclear facilities. The environmental assessment methodology and data can be applied to other nuclear facilities where plutonium is of concern.

Radioisotope Tracers Radioisotope tracers can be used to follow chemical reactions in biological and biomedical research. Radioactive isotopes, such as carbon-14 and hydrogen-3 (tritium), can be used to "tag" organic molecules. Because the tracer's radiation is easily detected, its movement can be followed through the diverse processes and changes occurring in the biological or physical system containing the radioactive tracer.

The following are examples of the successful application of radioisotope tracer techniques in the study of ecosystems and biological systems. The use of radioisotope tracers in medical diagnosis and treatment is discussed in the section on "Nuclear Medicine."

Linkages in Ecological Systems Use of radioisotopes as chemical tracers for food web (lateral food chain linkages) and related studies was developed to help understand and project the fate of radionuclides released to the atmosphere in weapons tests and by nuclear production facilities. These techniques soon played a key role in ecosystem investigations. In radionuclide studies, the tracers enabled researchers to distinguish the specific chains in an ecological food web. With this information they could trace the pathways and identify the processes that concentrated radionuclides as they moved from the environment to humans. More broadly, the successful use of radiotracers in this research area encouraged environmental scientists to use radiotracers for identifying and quantifying linkages in ecological systems that previously were difficult, if not impossible, to trace, thereby opening a whole new range of understanding ecology.

History A prime concern of the AEC and public health agencies was that radioactive materials might move and localize in the environment, thereby becoming concentrated before reaching humans. Recognizing that food webs were the major unknowns in understanding and predicting the fate of radionuclides in the environment and that radiotracers offer unusual possibilities for distinguishing specific pathways (food chains) in an ecological food web, AEC initiated a broad-based research effort on radionuclides and food webs. This research led to an understanding that organisms in ecosystems form feeding relationships and that these chains are usually limited to three or four links. A radioisotope of an element may be transferred up a food chain, concentrated, or discriminated against, at various levels, as it is passed to the next level through feeding and being fed upon.

As investigations yielded quantitative data on these processes, ecologists perceived the potential to use mathematical models in addressing the complexity and dynamics of ecosystems. By the end of the 1960s, ecosystem modeling based on radiotracer techniques was recognized as useful in addressing the Nation's environmental pollution problems.

Benefits The analysis of food chains with radiotracers confirms the importance of food in passing radionuclides to humans. Consequently, calculations and estimations of the radiological dose to humans must take into account the behavior of radioisotopes in food chains. These data are critical because the standards for the release of radioisotopes to the environment have become more stringent. In contrast to the early days of nuclear energy when estimates of release were based on limited laboratory data, detailed quantitative information can now be provided on the rates of accumulation and residence times of radionuclides in a variety of organisms. This ability has proven extremely important in the preparation of environmental assessments of proposed nuclear facilities and has enabled radiation protection specialists to derive dose estimates.

Dynamics of Biological Systems Carbon-14, which omits beta particles with a half-life of 5770 years, with slight toxicity, and hydrogen-3 (tritium), another beta emitter with a half-life of 12 years, are the two most widely used radioactive tracers in biomedical research. Ninety-five percent of the biomedical research reported in leading journals involves the use of these tracers. Research in biochemistry, physiology, and pharmacology relies on the continued use of these tracers.

Carbon-14 is the most popular isotope because of its favorable combination of properties. It emits beta particles strong enough to measure—but weak enough to make shielding unnecessary—and to give good definition in radiographs. Its long half-life makes it unnecessary to correct measurements for decay; and it is available in adequate quantities, with suitable levels of radioactivity, and at low cost. Its toxicity is relatively slight and is not a problem in most applications. Tritium has been used mainly as an auxiliary tracer for carbon rather than as a hydrogen tracer; its shorter half-life offers some advantages. Isotopes of other elements, such as hydrogen, nitrogen, oxygen, sulphur, and phosphorus, are of secondary interest but are valuable for certain uses.

History On June 14, 1946, in the journal *Science*, an announcement was made by Manhattan Project Headquarters, Washington, D.C., that:

> *Production of tracer and therapeutic radioisotopes has been heralded as one of the great peacetime contributions of the uranium chain reacting pile. The use of the pile will unquestionably be rich in scientific, medical and technological applications.*

On August 2, 1946, the first shipment of reactor-produced radioisotopes left ORNL. The compound containing carbon-14 was sent to the Bernard Free Skin and Cancer Hospital in St. Louis. This signaled the beginning of widely available isotopes at reasonable costs for persons trained in their use. By 1962 ORNL had made over half a million shipments of radioisotopes. On July 31, 1964, there were 1085 physicians in the United States licensed to use radioisotopes in private practice and some 1201 medical institutions licensed to handle radioisotopes.

Benefits The use of carbon-14 in biochemical analysis is widespread.

1. Carbon-14 glucose has replaced the classic glucose tolerance test in measuring the absorption of glucose. Molecules "labeled" with carbon-14 are structurally identical to the nonlabeled molecules and behave exactly the same.
2. Carbon-14-labeled compounds have simplified the study of metabolic diseases in man because only the amount of carbon dioxide labeled with carbon-14 ($^{14}CO_2$) in expiratory air needs to be measured. This method is easily applied using carbon-14-labeled tripalmitate or trioleate to diagnose the malabsorption of fat. Problems associated with radiochemical purity are avoided when carbon-14 compounds are used.

One of the most important advances in medical diagnosis was made with the introduction of tissue biopsies, providing information that formerly could be obtained only at a postmortem examination. Usual chemical methods cannot be used because of the small amount of tissue involved. Use of carbon-14 provides a sensitive, specific, and technically easy measurement of biological reactions in these isolated tissues, by measuring $^{14}CO_2$ liberated when tissues are incubated on surfaces containing carbon-14.

Carbon-14 is used mainly for in vitro, or test tube, studies of cells incubated on various carbon-14-labeled surfaces. One development at the Johns Hopkins University Hospital has been for rapid detection of bacterial contamination in various biological specimens. For example, blood or tissue suspected of harboring bacteria is placed in a reaction vessel in contact with an appropriate carbon-14-labeled material. The appearance of $^{14}CO_2$ in the gas above the reaction vessel will indicate the presence of bacteria more quickly than routine bacteriological techniques.

Other advantages of carbon-14 and tritium are the long shelf-life of radioactive-labeled compounds; availability in relatively pure forms; the ease of attaching radioactive atoms to proteins; and broad applications in the production of complex molecules with living organisms, drug metabolism, cytology, and enzyme assays.

Plant Metabolism A complete mapping of the metabolic pathways of carbon in the photosynthesis process from the initial fixation of carbon dioxide from the atmosphere to the production of glucose by green plants was developed by Dr. Melvin Calvin and associates at Berkeley from 1945 to the late 1950's. In 1961 Dr. Calvin received the Nobel Prize in Chemistry for this work.

History Once radioisotopes from reactors became available in quantities sufficient for research in the early 1950's, AEC encouraged the use of these isotopes and sponsored a variety of research relating to problems of fundamental significance. The association with the field of photosynthesis arose because the chemistry of metallic/organic compounds had been applied to the purification of plutonium and uranium during the Manhattan Project. Chlorophyll, the key molecule in photosynthesis, is one such metallic/organic compound and had been an area of research for Dr. Calvin prior to his work on the Manhattan Project. AEC subsequently provided both funding and isotopes to him for extensive fundamental research on tracing the complex physical and chemical processes involved in, or metabolism of, photosynthesis.

Other current directions of research, based upon understanding the physics and chemistry of photosynthesis, include the development of devices to convert solar energy directly into stable chemical forms and, on a longer-term basis, to reduce carbon dioxide in the atmosphere.

Benefits The scientific benefits of this work were twofold. First, understanding of the photosynthetic process was greatly enhanced. This understanding of the detailed biochemistry of the process laid the groundwork for further developments leading to an understanding of metabolic controls in plants. Such an understanding was a prerequisite to any genetically engineered plant modifications and led to commercial applications of chemicals specifically designed to accelerate plant growth and inhibit photorespiration.

The second early benefit was the demonstration of powerful research techniques that have since found extensive use in studies of both plant and animal metabolism. These techniques include the use of radioactive carbon-14 as a tracer to provide detailed autoradiographs (pictures revealing the presence of radioactive material, the film being laid directly on the object to be tested) of the physical movement of carbon atoms through tissues or samples and the use of autoradiography combined with paper chromatography (the separation of mixtures into their constituents by preferential adsorption by a solid, as a strip of filter paper) to identify the intermediate chemical products and enzymes associated with the metabolic path.

Extensive research has continued at Berkeley and throughout the world to further define photosynthesis, not only in terms of carbon dioxide fixation, but also in terms of photochemistry, electron transport, and the metabolic mechanisms that regulate plant chemistry and structure subsequent to the formation of glucose. The development of further metabolic understanding, the codevelopment by other researchers of a spectrum of genetic engineering techniques that permits the insertion of gene fragments into single plant cells, and the ability to grow many types of plants from a single cell have made it possible to modify selectively plant characteristics.

A potential future benefit of research of this type is the transfer of the light-hydrocarbon manufacturing capability of certain tropical species into plants that could be grown in the United States. Another possibility is the genetic improvement of the efficiency of the photosynthetic process itself.

Land Reclamation The program in reclamation of surface-mined land was begun in 1975 and has demonstrated that reclamation of such land is feasible both in the arid West and in the Midwest.

History Two fundamental research efforts in soil science and plant ecology aim at understanding the processes leading to long-term changes in soils and plants. This information is needed to define whether restoration following strip mining of coal is acceptably complete. OHER research focuses on plant competition, plant response to salt and water stress, soil biochemical processes, nutrient availability, and ecological processes of long-term significance affecting plant succession on disturbed landscapes.

The following examples of research efforts show that acceptable reclamation of surface-mined land is feasible.

Demonstration field plots at the Jim Bridger Mine in western Wyoming show that areas with unstored topsoil deposited directly on graded overburden can develop a stand of naturally occurring native plants 400 percent greater than that of a similar area covered with topsoil stored for 2 years prior to reapplication. Vegetation cover on the unstored topsoil plot almost equaled that on unmined areas after 5 years. With this information, the Bridger Coal Company now reapplies fresh topsoil whenever feasible. Because of weather and other factors, however, topsoil cannot always be deposited directly on graded overburden but, instead, must be stockpiled. How long can topsoil be stored before degrading? In 1981 DOE built an experimental topsoil stockpile, planted thousands of native plant seeds of known viability, and installed tubes for sampling gas and measuring soil density. With periodic testing of the viability of the seeds in the pile, the maximum period of storage for acceptable levels of seed germination is being determined. Periodic changes in soil microbial activity are observed in soil and gas samples from the pile. Results suggest that direct reapplication will enable operators to meet the 10-year revegetation period for arid sites mandated by the Office of Surface Mining, but use of stored topsoil may not.

A second, related project is the development of "super plants" adapted to mined-land reclamation in the arid West. The hybrid native shrubs are in the genus Atriplex (saltbush and shadscale) and, planted in the dry saline/clay environment found on mined land at the Navajo Mine in the Four Corners region of New Mexico and the Jim Bridger Mine in Wyoming, have survived better than any existing native plants. Current efforts include the development of optimum cultural practices and machine-harvesting methods for Atriplex seed. Commercial production of large quantities of improved hybrid seed is possible in the near future. A similar project was conducted on prime farmland (rather than on arid desert) at the Burning Star Mine in southwestern Illinois.

Benefits Coal companies, under the exemptions to current regulations allowed in some states, are beginning to use these innovative land reclamation methods. Proposed changes in requirements by the Office of Surface Mining will make these new methods available to all United States' coal firms.

Current estimates indicate that as much as 45 percent of the strippable coal reserves in the midwestern United States lies beneath prime farmland used for crops, areas similar to the OHER test area in southern Illinois. The method prescribed under the Federal performance standards for returning surface-mined land to row crop production is to remove and stockpile the topsoil, segregated by soil horizon, and then replace the horizons in their original order once mining is completed and the overburden is regraded. Not only is this elaborate procedure very expensive, but research shows that it is counterproductive.

The experiments performed at the Burning Star Mine in southern Illinois have so far revealed no difference in crop yield between segregated and mixed soil materials: removing, storing, and replacing the soil horizons did not increase productivity any more than dumping newly dug and mixed soils from the bucket-wheel excavator ("wheelspoil") directly onto previously mined land in a single operation. The ANL land reclamation program has calculated the cost of the latter procedure as $22,700/hectare in 1979, compared to $61,800/hectare for the practices mandated by the Office of Surface Mining.

If the above benefits are extrapolated for 20 years, the present value of the benefit would be $2.3 billion.

The amount of surface-mined coal from western fields was about 200 million tons in 1980 (assume that western coal is mined at a rate of 58,800 tons/hectare). The actual cost of land reclamation at a typical western surface coal mine, the Jim Bridger Mine in Wyoming, is about $54,400/hectare, of which earth-moving costs constitute about 75 percent. The direct-application method would save about one-half of this latter amount or $20,400/hectare. The potential benefits summed over 20 years would have a present value of almost $600 million.

Cheaper land reclamation offers at least two other types of social benefits of enormous significance: (1) the environmental damages avoided, such as habitat destruction, soil erosion, siltation of waterways, and visual degradation, and (2) the improved market position of an abundant domestic resource—coal—in relation to imported oil, and the associated favorable impact on the United States balance of payments and on National Security.

Detection and Measurement of Environmental Effects

Detecting Change Over the Ages The quantitative ratio of one radioactive isotope of an element to another isotope (radioactive or stable) of the same element can be used to date or trace the movement of the material containing those isotopes. The source of the radioactive isotopes may be geologic, continually generated naturally through cosmic-ray activity, or man-made, originating from weapons-test fallout or accidental releases. Many questions can be addressed using isotope ratios; for example, the age of volcanic ash on the ocean bottom, the rate of glacier building, the age of the Antarctic ice, the age and source of the water at the bottom of the ocean, groundwater age and motion, the speed of land erosion, the speed of winds traversing the atmosphere, and the exchange rate from the stratosphere of the Northern hemisphere to that of the Southern, to mention a few.

Two important applications of isotope ratios are the long-range tracing of effluents and establishing a historical baseline for assessing the impact on the world ecosystem of the recent buildup of radioactive and nonradioactive effluents.

History Beginning in the 1950's, the AEC undertook basic research using isotope ratio analysis techniques to understand the long-term dynamics of environmental processes. For example, W. S. Broecker and his colleagues used carbon-14/carbon-12 ($^{14}C/^{12}C$) ratios to estimate that the mean residence time of carbon dioxide in the atmosphere is about 7 years. Bottom water in the Atlantic turns over once in about 500 years and in the Pacific once in about 1000 years.

In 1958 Goldberg suggested the use of ionium/thorium ratios (^{230}Th/^{232}Th) to measure the accumulation of deep-sea sediments. A year later, he discovered silicon-32 in marine sponges and, with it, determined the rate of accumulation of silicious deposits. Perhaps his most important discovery, published in 1972, was the use of lead-210 for dating glaciers, currently the most widely used technique for dating recent (i.e., the past 100 years) lake and coastal marine sediments. In 1973 he and his colleagues published on the use of ^{228}Th/^{232}Th to show that many, if not most, lake and marine sediments have mixed, indicating a greater than anticipated role of bottom-living organisms in stirring up the bottom. Other OHER contractors have since found "bomb plutonium" 5 to 15 centimeters below the surface of sediments laid down over many centuries, indicating a more dynamic environment than previously believed. In 1976 Goldberg's associates showed that radon-226 could be used to help date sediments of biological origin deposited over the past 5000 years.

Scientists (Harley and H. L. Volchok) at the DOE Environmental Measurements Laboratory established the ratio of cesium-137 and strontium-90 in fallout and used this information to determine how quickly artificial radionuclides penetrated and moved in ocean waters and what factors (other than radioactive decay) changed the ratios. Oceanographers at Oregon State University measured Columbia River outflow to the sea by its chromium-51 content. Natural radon measurements were used to study the movement of underground water and the propensity of soil to retain introduced materials to judge the safety of waste disposal; PNL measured the natural interchange of materials between the air and seawater with beryllium-7.

Oceanographers at Hawaii and Livermore used fission products to measure the growth rate of corals. Woods Hole scientists used natural radionuclides to measure the absorption, desorption, and settling, that is, the processes that remove pollutants from the water and place them in the sediments.

Benefits Knowledge of how quickly the air is purged of pollutants, how pollutants are swept out of the ocean and into the sediments, how fast coastal waters flush, and where the materials in rivers are deposited provides important insights into the ability of the environment to accept human wastes. Thus, some basic issues can be addressed: the carrying capacity of nature's major sinks; the rate at which the land, air, and water can accept civilization's wastes; the time until cleansing mechanisms are operating; and the time and manner in which wastes break down into component parts.

Nuclear Medicine

OBJECTIVE: Develop to Its Highest Potential the Application of Nuclear Science to the Diagnosis and Treatment of Human Disease.

The phenomenon of radiation was recognized by early investigators to provide an opportunity for both improved health care and decreased health risk. It was foreseen that radiation provided a unique tool that, through application of the combined skills of scientists from the fields of physics, chemistry, biology, and medicine, could be made available in forms convenient for use by the medical profession for the diagnosis, as well as for the treatment, of human diseases. Nuclear medicine would make it possible to monitor body functions, isolate the causes and extent of diseases, and to treat these with methods never before possible.

Techniques that Aid in Diagnosis

Research programs sponsored by OHER have improved medical science's capacity to diagnose certain human illnesses. The use of radioactive elements that preferentially concentrate in certain body organs and that can be followed with very sensitive radiation detectors acts to make the body's internal organs visible to medical diagnosticians. This combination of selective radioisotopes and special instruments has decreased medical cost and simplified or made more effective some procedures. In general, radionuclides are injected into the circulatory system, the resulting gamma emissions are viewed with radiation detectors, and the detected signals are sent to a computer to be transformed into the images used in making the diagnosis.

The development of radioisotopes and their application to diagnosis, therapy, and monitoring of human health problems were accelerated dramatically by the formation of the AEC in 1947 and the establishment of a formal program to coordinate and expand efforts in this field. Nuclear reactors made it possible to generate enormous quantities of suitable radionuclides that could be incorporated into radiopharmaceuticals at moderate cost. In August 1946 the first reactor-produced isotopes for civilian uses (carbon-14 for cancer research) were shipped from ORNL. At the same time, large quantities of radioiodine were shipped to experimenters and clinicians; and in late 1946 S. M. Seidlin, L. D. Marinelli, and E. O. Shory (*J. American Medical Association*, 1946), announced the first effective treatment of thyroid cancer using iodine-130 and iodine-131.

Three examples of radionuclides widely used in radiopharmaceuticals are thallium-201, technetium-99m, and gallium-67, whose use has resulted in improved and less costly diagnosis with lower risk to the patient. Other medically important radionuclides include iodine-123, ytterbium-169, xenon-127, and xenon-133.

Thallium-201 for Diagnosis of Heart Disease Thallium-201 ion is a radiopharmaceutical used primarily for detecting cellular damage and reduced blood flow to the heart (ischemia). The thallium ions that have been injected intravenously are taken up by various organs in proportion to the blood supply of the particular organ. Approximately 85 to 90 percent of the radionuclide passing through the heart or its blood vessels is extracted during each pass. Its use for heart imaging is based on the relationship between thallium uptake and blood flow to that region and the integrity of the cells themselves. Therefore, reduced thallium ion in the heart region indicates either reduced blood flow, cell damage, or both.

Thallium scans can be performed immediately after exercise or at rest. The combination of an abnormal exercise image in the presence of a normal resting image indicates reduced blood flow to the heart. An abnormal exercise image that does not differ from the image at rest indicates previous cell damage and scarring. An abnormal exercise image that is more abnormal than one noted at rest indicates both previous cell damage and reduced blood flow.

History Heart imaging with radioactive particles was performed in dogs in 1966, and the feasibility of direct injection of radionuclide labeled particles into human hearts was demonstrated in 1970 using radioiodine. With the direct injection technique, virtually all radioactivity was localized in the heart and relative regional blood flow could be determined precisely. However, the inherent invasiveness and risks involved limited the application of direct injection to patients requiring cardiac catheterization.

Exercise-induced regional blood flow among patients with coronary artery disease using intravenously injected potassium-43 and rubidium-81 was demonstrated in the early 1970s. Thallium-199 and mixed thallium isotopes were used as imaging agents for heart muscle in the late 1960s under OHER support at the Franklin McLean Memorial Research Institute. Scientists at BNL developed the radiopharmaceutical production techniques for thallium-201 and demonstrated its use for heart imaging in the mid-1970s. This radionuclide is generated as the by-product of a process that starts with the bombardment by a particle accelerator of stable thallium-203 metal foils with protons.

The United States pharmaceutical industry invested between $20 and $25 million in developing the capacity to produce thallium-201. In 1981 about 370,000 thallium-201 scans were performed domestically. Thallium sales by the New England Nuclear Corporation alone increased from $14 million in 1979 to approximately $20 million in 1981. Worldwide thallium sales reached $28 million in 1980, up from $17 million in 1979.

Benefits The thallium-201 exercise testing has filled an important gap in the diagnosis of heart disease between electrocardiograph (EKG) exercise tests and the more invasive, risky, and expensive angiography using cardiac catheterization. This is especially true for females because false positive findings from exercise EKGs are much more frequent. Moreover, the inherent invasiveness, risk, complexity, and cost of angiography using cardiac catheterization weigh against its use to provide the necessary diagnostic information in a disease that affects over 500,000 Americans each year. The thallium examination not only extends benefits to those patients who would not be able to withstand cardiac catheterization, but it also results in better selection of those patients who require cardiac catheterization.

The introduction of a new technology into an already well-developed process produces an altered set of benefits and costs. For example, at the Johns Hopkins University Hospital between 1975 and 1977, 57 percent of the women who had cardiac catheterization to investigate chest pain showed no evidence of suspected coronary heart disease. In these cases, coronary angiography and simultaneous catheterization were required to be certain that the women did not have coronary heart disease. Today, nuclear cardiology procedures, chiefly thallium-201 exercise testing, have decreased this to less than 20 percent. Data from Johns Hopkins also indicate the increasing linkage of cardiac catheterization to cardiac surgery, with nuclear examinations solving nonsurgical diagnostic problems. The total National benefit has been estimated at over $70 million/year.

Technetium-99m for Diagnostic Scanning Technetium-99m is a radionuclide with a 6-hour half-life, favorable gamma-ray emissions, and no beta radiation. Depending on the chemical form, it concentrates in the liver and kidneys in a few minutes or in the skeleton in 2 to 3 hours after intravenous administration, thus allowing imaging with minimal patient radiation dose. Use of technetium-99m scans to examine prostate cancer patients identifies those—about 25 percent of the total—for whom expensive surgery or radiation therapy could be replaced by less expensive hormone therapies such as bilateral orchiectomy or exogeneous estrogens.

Technetium-99m is considered to have the best overall properties of currently available radionuclides for imaging with a scintillation camera (considering half-life of the radionuclide, patient radiation dose, gamma-ray energy, availability, and cost). Accordingly, it is used in over 80 percent of nuclear medicine examinations of the various body organs.

For routine diagnostic studies in adult patients, technetium-99m is administered intravenously in doses of 10 to 20 millicuries. Studies of the liver and kidney begin immediately. For the skeleton, imaging is usually performed 3 to 5 hours later.

It has been estimated that one in four patients hospitalized (out of 37 million admissions/year) in the United States received a technetium-99m-labeled compound as part of the diagnostic process. At least 6 million studies are performed annually. Industry is currently producing technetium-99m, with sales totaling $26 million/year.

History Artificially produced technetium is usually obtained from activated molybdenum-98. Technetium was discovered by Emilio Segre and Glenn Seaborg in 1938 at Berkeley, California, in the laboratory of Ernest Lawrence. Molybdenum-99 and its daughter nuclide, technetium-99m, were obtained as a result of the fission process.

For many years the medical possibilities of the use of technetium-99m were overlooked because of its relatively short half-life (6 hours). However, L. G. Stang, Jr. and Richards (working at BNL) invented the radionuclide generator, in which the user could chemically separate the technetium-99 radionuclide from its longer lived radioactive parent, molybdenum-99. This made possible the availability of the short-lived radionuclide at those sites where a reactor was not available.

Stang and Richards advertised both molybdenum-99 and technetium-99m for sale on the cover of the Brookhaven catalog of 1960. In 1961 Beck published a theoretical study demonstrating that the optimum gamma-ray energy for detecting brain tumors is below 200 kiloelectron volts, thus calling attention to materials such as technetium-99m. In 1963 Harper introduced a series of important compounds labeled with this nuclide. These compounds are used in medicine to diagnose disease, aid in planning treatment, monitor the response to treatment, and elucidate the cause of the disease. Technetium-99m-labeled compounds amenable to bone scanning were introduced in the early 1970s; labeled methylene disphosphonate and related compounds are now the primary agents used in bone scanning applications.

Benefits Technetium-99m currently has a broad range of diagnostic applications, as shown in Table 3. One important application of technetium-99m is its use in bone scanning to detect the presence of metastases associated with cancer of the prostate. Technetium-99m replaces isotopes of strontium that have high radiation levels, long half-lives, and poor physical properties, as well as isotopes of fluorine-18, which has high energy gamma radiation and must be produced in a cyclotron.

Table 3. Number of In Vivo Nuclear Medicine Examinations Performed by Organ System, 1982

Examination	Number of Millions
Brain	0.81
Bone	1.81
Liver	1.42
Lung	1.20
Thyroid	0.68
Kidney	0.24
Heart	0.95
Other	0.30
Total	7.41

Source: Mettler, F. A., et al., *J. Nuc. Med.* 26(2), 201–05, February 1985.

Cancer of the prostate is the most common cancer in men over the age of 50. The median age for the disease is 70. There are approximately 57,000 new cases and 25,000 deaths each year in the United States. Treatment for the disease varies with the severity and advancement of the cancer and ranges from surgical removal of the prostate (prostatectomy), or radiation therapy in less advanced or localized cases, to hormone treatment for relief from symptomatic pain in the more advanced or metastasized cases.

The use of technetium-99m bone scans enhances the diagnostic ability for early identification. Thus, costly radical prostatectomy surgery or radiation therapy can be avoided in patients with advanced cases where symptomatic relief is the appropriate treatment. Additionally, bone scans allow the physician to respond to various therapies or disease progression safely and noninvasively.

Prostatectomy has been used for decades by pioneering institutions such as the John Hopkins University Hospital as treatment for "curable" prostate cancer. Radiation therapy is an alternative treatment used by such major cancer treatment centers as Sloan Kettering Memorial Institute and is becoming more widespread.

A quantitative benefit of technetium-99m scanning was derived by computing (1) the net prostatectomy costs and (2) the net radiation therapy costs avoided. Averaging the net costs of the two treatments, assuming that one-half of the patients would have had prostatectomies and one-half would have had radiation therapy, yields an estimate of the cost benefit of about $92 million/year.

Gallium-67 for Diagnosis of Hodgkin's Disease Intraveneously administered radiopharmaceuticals containing gallium-67 emit highly penetrating gamma rays (with a half-life of 78 hours) and concentrate in tumors and abscesses. Gallium-67 was discovered at the Berkeley cyclotron in the late 1930s and was demonstrated clinically at Oak Ridge in the late 1960s. A two-dimensional image called a scintigraph is taken after 48 hours, using either a whole-body rectilinear scanner, a large-view gamma-ray camera, or a scanning gamma-ray camera. Gallium-67 scintigraphy is of great value in diagnosing cancer of the lungs and peripheral lung tumors that are not accessible by bronchoscopy. It is a valuable tool for monitoring response to chemotherapy and radiation therapy. The use of gallium-67 for localizing abscesses is increasing and may soon exceed its use for localizing tumors. Early detection of bone inflammation (osteomyelitis) by gallium-67 scintigraphy enables physicians to begin antibiotic therapy before extensive bone destruction occurs. The early use of gallium-67 in investigating "fever of unknown origin" frequently allows the physician to embark on a more fruitful, cost-effective search.

Currently, approximately one-half of all gallium-67 studies are performed for abscess localization and one-half for tumor diagnosis. In 1979 approximately 250,000 gallium-67 scans were performed in the United States at a cost of $5 million.

History The development of gallium-67 for use in detecting tumors and abscesses can be traced to the early 1950s, when H.C. Dudley at the Naval Research Laboratory (NRL) was conducting research on the toxicity of stable gallium-71. In the course of this research, it was noted that gallium-71 has an affinity for osteogenic (bone-related) activity. This led to investigation by ORNL, BNL, and NRL into applications of reactor formed gallium-72 embedded in stable gallium-71 for use in bone scanning. However, the short half-life (14 hours) and high energy of the gamma radiation (4 million electron volts) made this approach unacceptable.

In 1968 gallium-67 in gallium-71 was being evaluated as a new alternative for strontium-85 in bone scans. During this activity R. L. Hayes, C. L. Edwards, and others at the Oak Ridge Associated Universities observed that gallium-67 in its carrier-free form concentrates in tumors and abscesses as well, permitting their detection via gamma-ray spectrography. This observation sparked the development and use of gallium-67 for detecting tumors (*J. Nuclear Medicine* 13:92–100, 1972).

Benefits A single application of gallium-67 scanning as part of a diagnostic package for detecting Hodgkin's disease demonstrates the range of potential economic benefits from the use of this radioisotope. In the diagnosis of Hodgkin's disease, patients are classified into four stages based on the number of lesions in the lymphatic system. In stage one, the disease usually involves only one lymph node region and is usually treated with radiotherapy. Stage two involves two or more adjacent lymph node regions above the diaphragm and is also usually treated with radiotherapy. Stage three involves lymph nodes above and below the diaphragm and is treated with radiotherapy, supplemented by chemotherapy in selected cases. Stage four, characterized by more diffuse and disseminated involvement of the lymph nodes and other organs, is usually treated only by chemotherapy, with only relief and no cure expected.

The benefit of gallium-67 scanning arises from the ability to discriminate between advanced stages three and four of this disease and can be estimated as the avoided cost, about $10 million/year, of radiotherapy for individuals classified as stage four. Also important is the use of gallium-67 in follow-up treatment to evaluate remission or relapse, especially when confusing signs and symptoms appear. Symptomatic patients followed yearly, for example, can have recurrent disease that gallium-67 studies allow to be treated early and possibly more effectively. Conversely, many relapse symptoms are found to be falsely positive and not indicative of disease.

Instruments That Aid In Diagnosis

A key to novel and increased uses of radioisotopes in nuclear medicine has been improved instruments. Advances in imaging equipment that resulted from the post-World War II explosion in electronics and computer development had major impacts in improving detection sensitivity and the range of diagnostic studies that could be performed. The high-sensitivity Anger camera with sodium iodide (thallium) scintillators accentuated the significance of such radioisotopes as iodine-123 and technetium-99m, whose low particulate and gamma ray emissions are appropriate for camera use. Also, use of this modern imaging system allowed thallium-201 to be developed and utilized for diagnostic scanning of coronary artery disease.

The advanced imaging equipment allowed temporary concentrations of radioisotopes in various organs to be measured with good multidimensional spatial resolution. Thus, in addition to organ structural measurements, dynamic body functions such as circulation and organ metabolism could be measured. The Positron Emission Tomography (PET) scanner provides a good illustration of function-measuring capabilities.

When nuclear instruments were first developed by isolated groups of research scientists in different laboratories and institutions, the absence of standardization was not an important issue. However, as usefulness of these instruments increased, their use moved to other laboratories and the medical service industry. The demand grew accordingly, and the total investment became large. Therefore, plug-to-plug compatibility of instruments from various sources became both a scientific and an economic necessity. To address this problem, the Nuclear Instrument Module (NIM) system was developed under the OHER Program to provide a basis for replaceable plug-in instruments that form modules in power supply and instrument racks. The Computer Automated Measurement and Control (CAMAC) system which was to provide compatibility at other electrical interfaces and in data formats followed later and is now an international standard.

The Scintillation Camera The Anger scintillation camera allows the image of a photon (gamma ray) source to be reconstructed. It is the most widely used imaging device in nuclear medicine worldwide, being used for 80 percent of the studies on patients in nuclear medicine. It was invented to replace mechanical scanning.

The Anger camera uses scintillation crystals and photomultipliers to obtain serial images of the distribution of a radioactive tracer within the body at various times after the tracer is injected intravenously. The data are analyzed and processed by a digital computer and displayed on a video screen to provide quantitative information about regional biochemistry and physiology within virtually every organ of the body.

The Anger camera consists of a lead, multihole, collimator, a 10- to 15-inch-diameter sodium iodide scintillation crystal, a two-dimensional photomultiplier tube array on the crystal face, and a positioning logic network. The lead collimator allows only those photons traveling in the preferred direction (i.e., those that can go through the holes without being absorbed by the lead) to strike the crystal and cause it to emit light. The photomultiplier tubes closest to the scintillation event (pulse of light) produce the longest signal. An energy discriminator allows only those photons associated with gamma rays of specified energy level to be detected. Thus, the camera produces a signal showing the position of every scintillation event with the appropriate photon energy. A collection of these signals over time produces an analog image of the organ being viewed in the form of a two-dimensional projection of the three-dimensional distribution of radioactivity within the patient.

History The scintillation camera was invented by Hal Anger in 1958 at the Donner Laboratory, an AEC-sponsored facility. A number of improved versions of the camera have been developed, building upon Anger's original invention. Paul Harper of the Franklin McLean Research Institute, developed in the 1960s the scanning camera concept that permitted the camera's field of view to be extended to make whole body scanning possible. A new version of the camera permits rotation around the long axis of a patient. Images acquired at a number of angles around the patient are used with a computer for highlighting three-dimensional characteristics of organs or structures of interest.

Benefits The nuclear cardiology procedures that use thallium-201 and technetium-99m are performed almost entirely with this camera. Thus, the numbers cited for patients diagnosed and the benefits associated with thallium-201 and technetium-99m apply to the Anger camera as well. About one in four patients in American hospitals has an examination with the scintillation camera as part of the process of medical diagnosis.

Anger cameras are now being interfaced with digital computers produced by specialized nuclear medicine manufacturers. By enhancing the images produced, such computers allow improved visual interpretation. More importantly, because the images are stored in the computer as a matrix of numbers, quantification is possible. Using mathematical models of physiological processes, the combination of Anger cameras and computers permits noninvasive measurements that were not previously possible.

In 1981, 6740 cameras were distributed among hospitals of all sizes in the United States.

Scanning Instruments—PET PET scanning is a technique used in nuclear medicine to provide virtually three dimensional images of body functions. The technique measures the direction and intensity of gamma rays from a positron emitting radiopharmaceutical in the body.

Computer Assisted Tomography (CAT) scanning, which has been called the most important advance in medical diagnosis in a decade, uses X-rays and sophisticated computer technology to provide views of the body's interior, revealing in striking detail the anatomy and structure of various organs. PET scanning carries tomography one step further, depicting the active functioning of body organs, such as blood flow and glucose metabolism in the brain. Thus, PET represents "new" nuclear medicine.

A person undergoing a PET scan breathes or is injected with a small amount of a radiopharmaceutical labeled with a short lived radioactive isotope of some element that occurs naturally in the body (such as oxygen, nitrogen, or carbon). The radioisotope, produced in a cyclotron, emits positrons while undergoing radioactive decay. (Positrons are particles that have the same mass as an electron, but a positive charge.) The positrons are attracted to electrons associated with the normal matter in the body, and when the particles meet (and annihilate each other), two gamma rays (each with 511 kiloelectron volt of energy) are emitted in opposite directions (180 degrees from each other).

The gamma rays are detected using a ring of radiation sensitive crystals placed around the patient's head or body. When two gamma rays are detected by opposing crystals at the same time ("in coincidence"), the site of annihilation is assumed to be along the imaginary line joining the two crystals. The set of such lines detected over time from different pairs of crystals is fed to a computer, which reconstructs an image representing the internal distribution of the radioisotope. The image of body function or structure of interest is then displayed on a video terminal or recorded on film.

History The first imaging device to exploit the unique geometrical properties of the positron-electron annihilation reaction using scintillation detectors was constructed with OHER funding in 1953 by Gordon Brownell at Massachusetts General Hospital. The first PET scanner (PETT) was built by Michel Ter-Pogossian and colleagues at Washington University in St. Louis in 1974, with support from the National Institutes of Health (NIH). Scanners subsequently designed and built with support from NIH, DOE, and industry include:

1. PETT III, IV, V, and VI at Washington University;
2. Donner 280 crystal tomograph at the University of California at Berkeley;
3. Emission Computed Axial Tomograph (ECAT);

4. Neuro ECAT at the University of California at Los Angeles (UCLA);
5. Neuro PET at NIH; and
6. Other new tomographs at Massachusetts General Hospital, the University of Texas, and the University of Pennsylvania.

Several manufacturers, including Positron Corporation (Houston, Texas), CIT, Inc. (Knoxville, Tennessee), and Scanditronix (Sweden), now market PET scanners. The average cost of a unit is around $1 million. Clinical applications of PET have included imaging of the cardiac blood pool and blood flow in the brain and heart by the Phelps (1976); imaging of the heart, lung, and brain by Ter Pogossian (1976) and Budinger (1979); and imaging of the cardiac blood pool and blood flow by Hoffman (1979).

Benefits Perhaps the most exciting use of the PET to date is to study brain metabolism quantitatively. In such studies, deoxyglucose, an analog of glucose that is taken up by metabolically active areas of the brain as glucose, is labeled with carbon-11 or fluorine-18 and then injected into a patient's blood stream. PET provides three-dimensional views of the brain that quantitatively reflect the rate at which glucose is metabolized in different regions of the brain. Some remarkable findings have resulted from such studies:

1. Kuhl and colleagues at UCLA have scanned the brains of epilepsy patients, including some during seizures. The PET scans show that the brain cells that trigger a seizure are metabolically active during an attack. What surprised epilepsy specialists is that these same brain cells are less metabolically active between seizures than they are in normal people. The significance of this finding is as yet unknown.

   The UCLA doctors also have used PET to locate precisely the trigger site of seizures in patients where it could not be determined by other means. This has led to successful surgery in some previously inoperable cases.

2. NIH researchers have confirmed a theory that rare but deadly brain cancers called *gliomas* increase their metabolism when the speed of their growth increases. Doctors may delay operating on such tumors in their early stages because the surgery itself can do serious damage to the brain. The problem is that no good way now exists to determine the growth rate of the cancers. PET could be the answer.

Instrument Standardization Two standard instrumentation systems, the NIM and the CAMAC systems, were developed and coordinated as a result of efforts to improve the effectiveness and efficiency of scientific instrumentation.

The NIM system provides mechanical and electrical power supply interchangeability of scientific instruments and encourages a considerable degree of electrical signal compatibility. Mechanical interchangeability means that any NIM module (e.g., an amplifier) will fit mechanically into any NIM bin (a frame for holding modules). Electrical power supply interchangeability means that any NIM module, when inserted into any NIM bin, will be connected to the correct power supply. CAMAC includes these features plus the compatibility of digital signals and signal transfer processing, system interconnections, interfacing to computers and other processors, and associated software.

NIM and CAMAC are now the principal instrumentation systems used throughout the world in nuclear and radiation physics, nuclear chemistry, and nuclear medicine. Their use has also spread into other areas, including general laboratory and industrial research and industrial applications in process control and automated testing.

The CAMAC specifications are now industrial standards worldwide, having been promulgated by the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE), as well as by the International Electrotechnical Commission (IEC).

Approximately 80 firms supply NIM instruments and equipment. Over 50 firms manufacture CAMAC equipment. Major manufacturers of NIM and CAMAC instruments estimated United States sales for 1982 to be $23 million for NIM and $17 million for CAMAC. The United States market for NIM accounts for about 50 percent of the worldwide market, and the United States market for CAMAC accounts for about 60 percent of the worldwide market.

History Prior to the development of NIM and CAMAC, the users of solid-state nuclear instrumentation were severely limited in their ability to use the best available instrumentation. Instruments from different manufacturers often were neither electrically nor mechanically compatible. Consequently, the nuclear instrument user often had to choose to bypass the most appropriate instrument, to incur excessive costs by replacing all modules to obtain one new capability, or to design expensive ad hoc interface instruments.

In December 1963 the National Bureau of Standards, under contract to AEC's Division of Biology and Medicine (now OHER), urged that the National Laboratories develop a module that could become standard in all of those laboratories. Representatives of the National Laboratories met on February 26, 1964, to establish the NIM Committee and assign responsibility for developing a standard module system. Prototype bins and modules were produced by ORNL, LBL, and LLNL. The specifications for the NIM system were published in July 1964.

As automated and computer-linked nuclear instrumentation systems came into use, however, new compatibility problems arose. In late 1964 the Harwell Laboratory in England took the initiative to organize the development of CAMAC. In 1967 responsibility for the system development passed to the European Standards or Nuclear Electronics (ESONE) Committee of European Laboratories, which initiated close collaboration with the United States NIM Committee (still under OHER sponsorship). The ESONE NIM collaboration continues.

Benefits The benefits identified with the NIM and CAMAC standards include:

1. Flexibility and interchangeability,
2. Optimization of systems,
3. Ease of restructuring,
4. Deferred obsolescence,
5. Reduction of interfaces,
6. Ready interchange between installations,
7. Reduction of inventories,
8. Increased utilization of instruments,
9. Ease of serviceability,
10. Reduction of design costs, and
11. Savings in software costs.

These advantages can be translated into producer surplus or cost savings resulting from the use of NIM and CAMAC equipment. Annual benefits for 1982 were estimated to be $40 million. The present value of past and present cost savings associated with NIM and CAMAC between 1964 and 1982 totals $1.9 billion. Major factors contributing to these benefits are:

1. Fifty-percent reduction in data transfer speeds;
2. Lower equipment costs (CAMAC users indicated that equipment cost for a CAMAC system can be 20 to 40 percent lower than the alternative); and

3. Reduced inventories (interviews with National Laboratory personnel indicate that for every NIM or CAMAC model in inventory, at least four of an alternative instrument would have to be in inventory).

Treatment

Nuclear medicine has promoted new medical treatments directly and indirectly. Direct results have come through the use of radioisotopes that are specially produced and economically available. Treatment procedures have been modified by the involvement of a broadened range of scientific disciplines such as physics, radiation health physics, and electronic engineering. These disciplines brought a new dimension to medicine.

The direct use of radioisotopes includes cobalt-60 for the treatment of tumors, cesium to power implanted heart pacemakers, and the use of special radiation beams, as well as complementary instrumentation. Economic availability also greatly enhanced the use of radioiodine in thyroid treatment. Among the most recent experimental results is the treatment of tumors with radioactive monoclonal antibodies. Iodine-131 to treat hyperthyroidism and thyroid adenomas (benign or low malignancy tumors) typifies the use of radionuclides for medical treatment.

The use of radioisotopes in diagnosis allowed the tracing and understanding of body functions (especially the immune and blood systems) not previously possible. These new understandings promoted the indirect benefits of new nonnuclear treatments. For example, studies to develop specific inhibitors of protease enzymes resulted in the discovery of a compound that acts against thrombin, an enzyme that induces blood clotting. The compound has been patented and is used as an anticoagulant. Another example is the development of L-dopa (levodopa) for the treatment of Parkinson's disease.

Iodine-131 Therapy for Hyperthyroidism Iodine-131 is a radioactive isotope that concentrates in the thyroid gland and, thus, can be used in the diagnosis and treatment of thyroid disorder. This isotope has an 8-day half-life and emits high-energy beta particles and gamma rays in the region of 360 kiloelectron volts and higher.

Hyperthyroidism is a hypermetabolic state, caused by excessive levels of circulating thyroid hormones, which contributes to a variety of clinical symptoms. The dose of iodine-131 that concentrates in the thyroid gland destroys abnormal, hyperactive thyroid tissue that is producing excess hormone. This treatment, therefore, allows the gland to return to normal activity without surgery, hospitalization, or adverse effects on other tissues.

History In late 1939, J. G. Hamilton and M. H. Soley (University of California-Berkeley) published a paper on the first use of iodine-131 in patients with benign thyroid disease. In early 1941 the first patient was administered a therapeutic dose of iodine-130 and iodine-131 at MIT, and in late 1941 iodine-131 was used therapeutically against toxic goiter disease at Berkeley. In mid-1946 iodine-131 from nuclear reactor fission products was being shipped from ORNL, and in late 1946 iodine-131 was used by Seidlin for successful treatment of metastasized thyroid cancer. Until the mid-1960's, iodine-131 was the main nuclide used for the diagnosis of many diseases. After the mid-1960's, many diagnostic uses of iodine-131 were supplanted by technetium-99m labeled compounds. Iodine-131 is still extremely important, however, in evaluating thyroid condition and thyroid cancer therapy, for studying thyroid uptakes, and for thyroid imaging.

Benefits Radioactive iodine-131 is used in about 12 percent of all nuclear medicine procedures and is a good exmple of the use of radioactive therapy. Over the past 10 years at the Johns Hopkins University Hospital, surgery for hyperthyroidism has decreased drastically from 3000 to 4000 cases/year to a current level of 50/year. This reduction can be attributed to the use of nuclear medicine therapy with iodine-131.

In the United States, radioactive iodine is the preferred treatment for adults suffering from hyperthyroidism. Because peak occurrence of hyperthyroidism occurs between the ages of 30 to 50, approximately 85 percent of hyperthyroid patients are now treated with radioactive iodine. The alternative medical treatments for hyperthyroidism are surgical removal of the thyroid gland and drug therapy. Surgery is invasive, painful, and expensive and carries a significant risk of complications and, possibly, death. Drug treatment can be long term, can have serious side effects, and, in many cases, may still require subsequent surgery. The comparative costs (in 1982) of surgery and iodine-131 treatment reported for a medical teaching center were $7400 and $600, respectively. The reported overall incidence of hyperthyroidism in females and males is, respectively, 4.7/10,000 and 1.06/10,000. Thus, the total estimated savings in treatment cost because of the use of iodine 131 could be as high as $280 million/year (based on the United States incidence of hyperthyroidism in 1980).

L-Dopa Treatment for Parkinson's Disease L-dopa [(-)-3(3,4-dihydroxyophenyl)-L-adamine or levodopa] is an amino acid used in the treatment of Parkinson's disease. Oral administration of L dopa substantially slows the rate of progression of the disease, reduces symptoms, and decreases the mortality rate.

Parkinson's disease is a progressive neurological disease that produces tremors, inability to plan or initiate a movement, inability to control movements, rigidity, and disturbance of postural reflexes. The disease is characterized by a marked deficiency of a chemical called dopamine in the brain, the cause of which is unknown in the majority of cases. Parkinson's disease mainly strikes the aged, with onset between the ages of 50 and 70 in two-thirds of the cases. However, a rare juvenile form also exists. The disease affects close to one million persons, and there are 50,000 new cases each year.

Following its clinical introduction, L-dopa quickly became the preferred treatment and remains so today in a number of derivative forms. Although it does not cure the disease, it retards progress toward complete debilitation so that patients remain functional for several additional years. Symptoms present at the initiation of L-dopa treatment are generally reduced dramatically but reappear gradually, along with other symptoms that may be associated with the therapy.

In a broader context, L-dopa represents a dramatic advance in the treatment of diseases of the brain. It has provided a rational approach to medical treatment based on brain biochemistry and has stimulated interest in research on neutral diseases based on similar biochemical principles.

History In the early 1950's, there was widespread interest in the biochemistry of trace metals, and the use of radiotracers was developing. Dr. George C. Cotzias of BNL was searching for a research area employing radioisotopes of trace metals to study the chemical effects of the metals in humans over long periods. Links between manganese poisoning and Parkinson's disease had been discussed in the literature. Dr. Cotzias investigated manganese-56 because it was easy to make and had an appropriate half-life.

Although it turned out that there

Table 4. Life Expectancy for Pre-L-dopa and Post-L-dopa Treatment

Age at Onset of Disease (Years)	Normal Life Expectancy (Years)	Life Expectancy (Years)		
		Pre-L-dopa[a]	Post-L-dopa[b]	Post-L-dopa[c]
50	23	13	19	20
60	15	8	11	12

[a] Excess mortality rates calculated from Hoen and Yahr, " ," *Neurology* 17, 427-42 (1967).

[b] Excess mortality rates calculated by Macdowell, Papavasilou and Sweet, 1979,

[c] Excess mortality rates calculated by Diamond and Markham, 1979

was not a good connection between Parkinson's disease and manganese poisoning, several important new areas of research evolved from these studies. One stemmed from Dr. Cotzias's understanding, gained in his research, of how the chemical balance in the body gradually changed when a new substance was introduced.

The deficiency of the amino acid dopamine in the brains of persons suffering from Parkinson's disease had recently been discovered. Although it was not possible to introduce dopamine directly into the brain, it had been postulated that intravenous introduction of its metabolic precursor, levodopamine, might correct the brain dopamine level. Short-term clinical trials were unsuccessful; however, they were inconclusive and produced adverse reactions.

Dr. Cotzias recognized the need for very gradual L-dopa administration over long periods. The research hospital at BNL provided the capability for the necessary clinical trials, which proved successful. The first report of long-term L-dopa treatment was published by Dr. Cotzias in *The New England Journal of Medicine* in 1968, and a follow-up report on the results of a 2-year clinical study was published in the same journal in 1969. A February 1969 editorial described his work as "the most important contribution to medical therapy of a neurological disease in the past 50 years." Dr. Cotzias received the Albert and Mary Lasker Award for Experimental Medicine in 1969.

Benefits The two major benefits associated with the use of L-dopa in the treatment of Parkinson's disease are extension of life expectancy and delay of disability.

1. *Extension of life expectancy.* Two studies provide a basis for measuring the effect of L-dopa treatment for increasing the life expectancy of a patient. The first study followed a group of 100 patients on L-dopa therapy for 10 years beginning in 1968. During that period, 56 died, leading to a calculated excess mortality ratio of 1.54 for untreated patients. The second study surveyed a random sample of 327 patients who were being treated with an L-dopa derivative over a 5-year period and found an excess mortality ratio of 1.42 for untreated patients. These figures can be translated into an individual life expectancy extension for treated patients with an assumed age of disease onset (see Table 4).
2. *Delay of disability.* L-dopa therapy has also been found to produce moderate to marked improvement in 50 to 75 percent

of Parkinson's disease patient's ability to function. Two studies demonstrate the initial improvement and subsequent decay of independent performances of patients treated with L-dopa.

A disability index related to symptons and ability to perform normal functions was calculated at various times during the 10-year period. For the 41 patients who remained in the study throughout the period, the average disability index improved initially, but at the end of 10 years, the index was the same as that prior to treatment. However, although the indices had the same value and the impact on independence was similar, the specific disabilities at the end of 10 years were not primarily motor- and tremor-related as in the initial situation, but tended more toward instability and dementia.

In a private communication, Dr. Thomas Presiozi of the Johns Hopkins University Hospitality Neurology Department confirmed that about 80 percent of the deaths of Parkinson's disease patients are actually due to causes unrelated to the disease or its effects.

The Future

This account of selected accomplishments over the 40-year program of energy-related health and environmental research only partially illustrates its role in fulfilling an important National need. Use of this style of presentation makes it difficult to convey the program's most important characteristics: an evolutionary, integrated, and multidisciplinary research commitment; a synergism between fundamental science and applied problem solving; and an inevitable share of scientific setbacks, as well as achievements. Thus, in reality the accomplishments represent a continuum of scientific development from the basic unraveling of bio-environmental processes and the coupling of seemingly disparate facts to their application to specific problems.

These program characteristics, in turn, lend a distinct characteristic to the research itself; it draws continually upon an established base of knowledge, the rewards becoming increasingly apparent far downstream from the initial thought and investment. Thus, to a large extent, the program's future accomplishments are already embedded in its studies of the past and the present.

As a part of the evolving National energy mission, a responsive research program has developed the expertise and facilities required for its newer roles. The evolution continues, centered around a long term commitment to fundamental and basic research and aimed at addressing problems and issues of a high-risk nature with an anticipatory rather than a regulatory approach. Of particular importance to the future is the fact that the program's multidisciplinary talent and capabilities in unique, dedicated facilities constitute a valuable National resource.

The research program is, therefore, as well equipped to meet future challenges as it was to meet past challenges. As our energy mission continues to evolve, with changing patterns of energy demand and the accompanying development of responsive new sources, it is reasonable to expect research contributions to assure safety, acceptability, and compatibility with the National goal.

The promise for the future, therefore, lies within the Program's traditionally interactive and interdisciplinary approach to complex problems. New biophysical and chemical tools and techniques in biomedical and environmental research now make it possible to attempt unprecedented studies on cells, molecules, and processes relevant to the triad. These technical advances, applied to basic studies, will continue to contribute answers to energy related questions, as well as to increase knowledge about causes and effects in biological systems. As in the search for radiation repair mechanisms that led to discoveries of DNA behavior and important theories of the nature of human disease and its treatment, the Program's research will continue to lead in making fundamental and practical contributions in reducing uncertainties about the health and environmental aspects of emerging energy technologies.

Appendix The Health and Environmental Research Program

The Office of Health and Environmental Research (OHER) manages the Department's Biological and Environmental Research (BER) Program. The mission of OHER is to develop and sustain a high quality basic and applied research program at the frontiers of biomedical and environmental science consistent with the mission of the Department of Energy (DOE) and the objectives of the Office of Energy Research. More specifically, the OHER program objectives are based on the following considerations:

1. OHER is the principal organizational unit within DOE for conducting research on environmental and human health effects of energy strategies. The objective of these research programs is to develop principles and broadly generalizable knowledge that will be needed to address the wide range of questions that must inevitably be faced by future generations as well as by our own. OHER, therefore, is committed to using the most advanced scientific methods and technologies to explore the fundamental issues bearing on assuring safe energy operations, for example, the molecular and subcellular mechanisms which underlie human cellular, genetic, and environmental pathology and toxicology.

2. The Office recognizes that the unique facilities and computational capabilities, as well as interdisciplinary breadth and depth of skilled scientists at the National Laboratories, offer the Nation an important opportunity for addressing a wide range of important research and development problems. Programs in the area of nuclear medicine have contributed substantially to the health and economic well being of the Nation. OHER is committed to further development of these and other areas, such as biotechnology and related capital intensive long term projects in structural biology, which fully utilize the human and technological resources of the National Laboratories.

3. OHER views the National Laboratory system, research universities, and the private sector, as members of the same team working toward the solution of some of the Nation's most important problems. The Office is, therefore, dedicated to encouraging synergism between these three research sectors by various means, including stimulating access to advanced multiuser research facilities at the National Laboratories; the support of student fellowship and faculty sabbatical programs for collaborative research at National Laboratories; and the transfer of tools and technologies developed at the National

Laboratories to the private sector and universities.

To attain these goals, a number of interdependent research objectives are addressed. The major objectives of the program are to:

1. Develop new concepts, procedures, and instrumentation for detecting and measuring energy related physical and chemical agents released into the occupational and general environment;
2. Characterize the long term atmospheric transport and chemical transformation processes of radionuclides and energy related chemical effluents to improve estimates of dispersion and potential human exposure;
3. Elucidate the mechanisms that control natural ecosystems and the processes that influence cycling of nutrients and energy related materials through terrestrial and aquatic ecosystems and to measure ecological effects resulting from energy related stresses to better predict environmental impacts and resiliency;
4. Quantify the late biological effects of exposure to ionizing radiation through long term human and experimental animal research;
5. Resolve the uncertainties associated with carcinogenic, mutagenic, and toxic effects of energy related chemicals and complex mixtures of chemicals;
6. Define mechanisms involved in the induction of biological damage following exposure to low levels of energy-related pollutants by supporting research on biomolecular structure, gene function and control, genetic damage and repair, and cell transformation; and
7. Develop new approaches, instruments, and methodology for the improved diagnosis and therapy of human diseases, and in the study of human physiological processes, including the brain and heart.

The research is carried out in the following major program activities.

Health Effects Research This program is primarily concerned with evaluating the delayed types of health effects—tumors, heritable defects, developmental effects, and damage to body organs—that are caused by chronic low-level exposure to energy-related physical and chemical agents. The research utilizes molecular, cellular, and animal test systems to obtain quantitative data on dose response relationships and to develop an understanding of differences in species sensitivity. Because credible extrapolation of such data to man requires a knowledge of the mechanism underlying the induction of adverse effects in different species and because the production of delayed effects is not clearly understood, extensive use is made of generic and basic research to provide experimental systems, techniques, and insights having the broadest application to health-risk prediction. Included is the development of improved biological test systems and improved techniques for the extrapolation of experimental data to man.

Health effects research cuts across virtually all of the energy technologies. Areas of ongoing research include those that address health effects associated with the broad spectrum of ionizing radiation and a variety of energy-related chemicals, including indoor air pollutants, PAHs, and related compounds associated with synthetic fuels production. Extensive research is conducted to elucidate the mechanisms which cause cancers and mutations, metabolism of energy-related chemicals, and mechanisms of DNA repair. Categories of research include:

1. Carcinogenesis (the production of cancer)—Both established and developing energy technologies produce or involve physical and/or chemical agents that can cause human cancer. Carcinogenesis research emphasizes evaluation of the tumor-causing potential of such agents, detection and characterization of carcinogens, elucidation of pathways and ways to detect formation and growth indicators of tumor, investigations to correlate exposure conditions (carcinogen dose) with tumor incidence in animal populations, and elucidation of mechanisms of carcinogenesis.

   Because the production of cancer is a complex process that may include discrete initiation and promotion steps, research into cancer induction often involves the study of complex interactions among different causative agents. Emphasis is also being given to researching free radicals and other oxidizing species that play a role in both chemical and radiation carcinogenesis.

2. Mutagenesis (the production of mutations)—Alteration of genetic material by physical and chemical agents may produce heritable defects as a result of mutations in reproductive, or germ, cells. Mutations in nonreproductive, or somatic, cells may result in cell modifications, leading to cancer or other health effects. The mutagenesis research program emphasizes investigations of the mutagenic potential of energy-related physical and chemical agents; metabolism of chemical agents in target cells; correlation of mutation frequency with level of exposure to a mutagen; evaluation of health consequences that mutations may produce at the population level; measurement of chemical damage to DNA formation; and elucidation of mechanisms of mutagenesis, including the relationship of mutagenesis to tumor induction. Effects on germ cells (chromosomal modifications) are also studied in detail.

3. Systems damage—Many hazardous environmental agents manifest their toxic potential by impairing one of the body's functional systems. Such effects—particularly delayed impairment of the respiratory, immune, nervous, reproductive, and blood forming systems or the developing embryo/fetal system—may lead to chronic disease with attendant health costs. The major efforts in this research area include the identification of early indicators of biological damage, interspecies comparison of major functional systems and their sensitivity to environmental agents, the development of improved biological test systems, and the conduct of dose response studies that support risk estimates for man.

4. Basic research—This is a substantial research effort aimed at providing the mechanistic and conceptual foundation that is needed to understand how physical and chemical agents interfere with life processes. Emphasis is on molecular and cellular studies to elucidate the normal structure and function of key biological systems or processes. Included is research in biophysics (structure of macromolecules and organelles), genetics (including DNA damage and repair), and cell biology (cell growth, cell differentiation, and cell regulation]

Human Health and Assessment
The Human Health and Assessmer program supports research to provide information on the response of individuals and human populations to toxicants and the feasibili of using nuclear technologies in biomedical applications.

1. Human health research—This program ascertains by epidemio-

logic studies the potential spectrum of human health problems associated with occupational and environmental exposures to radiation and chemicals in DOE operations and emerging energy technologies. Investigators also detect and measure genetic and significant subclinical changes in exposed humans that can serve as early indicators of latent disease induction or to identify particularly sensitive individuals.

2. Medical applications of nuclear technology—This program exploits the Department's interdisciplinary cadre of investigators and technological resources in physical, chemical, and computational sciences to develop and evaluate new approaches, instruments, and methodology for the improved diagnosis and therapy of human diseases and in the study of human physiological processes. Current emphasis is on the development, production, and evaluation of new radionuclides, labeled pharmaceuticals, radiation beams, imaging devices, and enriched stable isotopes.

Physical and Technological Research This is the physical sciences component of the health and environmental research program that addresses a broad range of fundamental and applied activities. Many of the projects interact with the biological and ecological components of the program. Other projects involve the development of experimental techniques or advanced measurement instrumentation. The major areas addressed are the physical and chemical characterization of products and effluents of new energy technologies, the transport and transformation of pollutants in the atmosphere, measurement science, health and safety, and the fundamental mechanisms of pollutant interaction with environmental and biological systems. Categories of research activity include:

1. Analytical Characterization—The distribution, concentration, and the physical, chemical, and radiological properties of emissions and effluents associated with energy-technology processes are determined. Field sampling and measurement and laboratory studies provide detailed information on the chemical and physical properties of collected materials.

2. Atmospheric Transport and Transformation—This category includes research to develop an improved understanding of meteorological, chemical, and physical processes that influence the transport, transformation, and fate of gaseous and particulate species emitted into the atmosphere. Improved atmospheric dispersion models are developed and validated through field experimentation.

3. Measurement Science—New concepts and improved measurement systems required to address environmental, health, and safety concerns related to energy production are investigated. Research covers a broad scope of activities ranging from the basic science of measurements to the construction and evaluation of prototype instrumentation systems.

4. Radiological Physics and Chemistry—This is a fundamental research program of radiological physics and chemistry directed toward understanding the entire chain of events from the initial radiation interaction process to the eventual biological effect. Both theoretical and experimental research investigate the mechanisms of radiation energy deposition and transfer in simple systems and extends this understanding to more complex and biologically relevant systems.

Ecological Research The ecological research program provides the scientific information base needed for appropriate siting, operation, and disposal of materials from energy activities. To obtain this information base, comprehensive basic research in terrestrial and aquatic systems is conducted in different climatic regions of the United States and in off-shore regions along the eastern and western United States on mechanisms that influence and control total ecosystems. The research is carried out by integrating all aspects of the physical and biological sciences. This multidisciplinary program includes experts in soil science, plant science, animal biology, chemistry, geology, and freshwater and marine sciences.

Research describes how energy by-products move and are acted upon by plants and animals in terrestrial and marine systems and identifies the major routes and rates of transfer of these by-products back to humans. Natural and energy-related stresses are studied from the subcellular level to the community level of ecosystems to determine the rate and mechanisms by which populations and ecosystems disturbed by energy activities adapt or react to these stresses. Categories of research opportunity include:

1. Cycling of natural and energy materials that include mobilization and movement of trace elements and compounds through water bodies, soils, sediments, plants, and animals. Research into the cycling of energy introduced substances is coupled to research into the cycling of normally required nutrients to permit the most appropriate cost effective measures to be developed for redistribution and control of energy materials in the environment.

2. Biologic responses derived from community structure, population dynamics, and physiological ecology research. Knowledge of accommodation by plants and animals to natural stresses is used to allow energy-related activities to expand while taking into consideration limits of ecosystem stress. Processes of natural succession are studied to determine if disturbed land is best left to natural revegetation or whether revegetation can be accelerated or improved by scientific means. Research is carried out on metabolic proesses that accumulate exposure levels allowing ecosystems to exist without serious adverse impacts.

Facilities Facilities playing important roles for addressing radiation and energy-related chemical issues include the Radiological Research Accelerator Facility at Columbia University, the Health Physics Research Reactor at ORNL, and the Janus Reactor at ANL. These facilities provide a spectrum of relatively pure neutron beams over a wide range of doses and dose rates for studies in radiation biology, radiation dosimetry, and for training activities. The Environmental Measurements Laboratory (EML) develops improved techniques for radiological and chemical measurements to characterize the chemical and radiological content of atmospheric, soil, and water samples and provides DOE with a rapid response capability for obtaining needed field data. For example, EML recently completed a reassessment of population dose in Utah from weapons testing based upon their measurement of soil and water levels of cesium-137.

The National Environmental Research Parks (representing protected sites around five National Laboratories with a diversity of flora, fauna, and climate) have for two decades served as outdoor laboratories for quantifying ecosystem responses to a wide range of energy activities, including coal combustion, overhead transmission lines, reactor operations, and burial of radioactive wastes.

A three-stage mass spectrometer, installed at the Savannah River Laboratory, provides accurate and precise analysis of isotope ratios for very low levels of environmental radionuclides, defining their source and time sequence of deposition in terrestrial and aquatic experiments under field conditions.

Advanced flow cytometers, developed at Los Alamos and LLNL, are also being used by DOE and other sponsors to identify and separate specific cell populations, and purify chromosomes for gene mapping studies to produce template material for making chromosome—specific human gene "libraries" for distribution to the scientific community.

HEALTH AND ENVIRONMENTAL RESEARCH

Dr. TRIVELPIECE. Here is one that talks about the health and environmental research activities in the Department of Energy. It starts with the Atomic Energy Act of 1946 and 1947, and it talks about the fact that you now have nuclear materials, and the nuclear materials do two things. One, they provide you with a new opportunity, and the other is that there are some risks associated with using them.

That law called into being, in effect, the Division of Biology and Medicine in AEC. One thing that they were supposed to do was to see what the risks are, understand how to mitigate against them and handle them, and the other was to take advantage of the nuclear materials to see what could beneficially be done.

I think that it was a very creative law, because the effect of that law is the creation of the whole nuclear medicine industry, as well as our understanding of the biological effects of ionizing radiation. Almost everything we know about it comes from that.

As time has gone by, and other energy sources have come into existence, people become concerned about where materials come from, and where they go in the biosphere, and what they do when they get into human beings. In the past, much of this information was gained by using a large number of small rodents, irradiating them, or subjecting them to chemical insult and seeing what happened as a result of that. Painting coal tar on the skin of certain kinds of mice, and so on.

As molecular biology has improved, we no longer use a large number of small animals, or even a smaller number of larger animals, but are, in fact, capable of going down and exploring this at molecular levels. So what you would like to know is what do various chemicals and radiation do down at the molecular biology level.

In order to do that, you would like to know what happens to DNA. What happens to DNA involves trying to understand the whole process of repair, how cells repair, how cells are damaged, how certain cells become unregulated, and the whole oncogene business.

DOE is doing this sort of thing, which sounds a little bit like a human health issue. But, in fact, many of the tools that are currently used by the health industry in doing the research, such as flow cytometry, which permits understanding damage to cells by literally separating one cell per hundreds of thousands or 50,000-per-minute kinds of rates.

These tools have come about as a result of the combined physics, chemistry, mathematics, engineering, and biology efforts that DOE laboratories can bring to bear. As almost a natural outgrowth of that, we are now at a point where, because of some of these tools exist, large-scale digital computers, the ability to handle millions of cells and to be able to separate out various pieces of DNA fragments, we are now at the point that we can consider literally making a blueprint for the human being.

The human being has something like 24 chromosomes, and each chromosome has something like 50,000 genes, and each of the genes is made up of long strings of the various DNA base pairs. You can begin to think in terms of making something like a periodic table, or doing for biology what the periodic table did for chemistry and physics.

The current rate at which you can go about sequencing human genetic material is probably $1 per base pair. If you use the numbers I quoted in terms of how many genes and chromosomes and base pairs there are, it is probably 3.5 billion, so at a $1 apiece, it is $3.5 billion. It would take a long time and it is probably not worth doing that way, but the technology is such that it is on the threshold of being able to do this at a cost of 1,000th of that, or maybe 10,000th of that.

DOE RESEARCH CAPABILITY

DOE is strategically well placed to be able to do this kind of research, the robotics, the computer technology, the ability to handle the quantities of genetic materials to take the snippets of genetic material in DNA and order them, and find out what their sequence is, and find out what their function is.

Senator JOHNSTON. Let me ask you. We have learned to digitalize music and reproduce it from the digits. Do you think that we could digitalize a human being, given enough money?

Dr. TRIVELPIECE. You could identify for the first time what is the order of the chemical makeup of the human being from one end to the other. You can do this with small cells now. But you could literally write down in 3.5 billion sequential chemical formulas what the chemical makeup is of the entire human genome. It is a remarkable possibility. To even be able to consider that is remarkable.

Senator JOHNSTON. And have that instead of a social security number? [Laughter.]

Dr. TRIVELPIECE. That would indeed be a social security number that you could rest assured no one else would duplicate.

The process, in our view, of what needs to be done is not setting out to map and to sequence the entire genome. It should be done in two pieces. One is to take large pieces of DNA, this is the snippets, and so on, and find out what the gene functions are of these things as they relate to one another.That is a much less expensive process. We are asking for a $10 million increase, and next year it is about $11 million total.

This money is not going to be devoted to just going out and blindly sequencing these things, but rather to try to develop the technology that will permit this to be done more efficiently, the robotics and the computer technology that needs to be put together. For example, whatever this will cost, a few hundred million dollars is probably more like the cost than several billions of dollars.

The information needs to be generated and stored archivally, and it is a large amount of data. This gets into large database set management computer technology. If you do that poorly, the data, no matter what it costs, will not be usable in the subsequent generations. People need to think about the computer science of this, as well as the biology, and the mathematics, and the physics, and the engineering that goes into it. It needs to be an integrated program.

We think that the kinds of things that have been done in DOE laboratories in the past in this area have made them ideally suited to carry on this task, but it is clear that the task has the interest of a lot of other agencies, HHS, NIH, and so on. There is some coordination going on that level.

It is an important activity. I think that it is a fascinating idea that you can try to understand what happens, how cancers are caused, how chemistry influences the human makeup, and so on. It is important from an energy point of view, and it is important from just an ordinary health point of view as well. We are working with NIH to try to move this along.

Senator JOHNSTON. I personally think that DOE's work in health has been cost effective and very good. I want to encourage that. You have done, and you are in a position to do very good things in health. Our assets in the national labs at DOE facilities are the finest in the world, and I think that it is well to devote those to these health initiatives.

WRITTEN QUESTIONS SUBMITTED FOR THE RECORD

Dr. Trivelpiece, thank you very much. As I said, we have a number of written questions for the record. I also understand that several other members have questions as well.

We will see you again at our Committee on Energy and Natural Resources, so this won't be your swan song on the Superconducting Super Collider, or any of these other goodies, but it may be your swan song before this subcommittee. Thank you very much for being here.

Miss Fitzpatrick, thank you very much for excellent testimony, and the same to you. It was a pleasure to have you here.

[The prepared questions and answers follow:]

QUESTIONS SUBMITTED BY SENATOR JOHNSTON

Superconducting Super Collider

Question: We will go into the SSC proposal in more depth later on but for the purposes of this appropriations hearing, please tell me why you need $10 million of the $35 million requested for FY 1988 for construction purposes.

Answer: The Department has requested construction funding in FY 1988 to give a basis for the Congress to approve initiation of the project in FY 1988. This will permit the Department to proceed with site selection and provide a basis for an FY 1989 request for substantial funds for SSC construction. The FY 1988 funds will be used for selected long lead procurements and detailed design of technical systems which are independent of site.

Question: Does this $10 million request actually involve construction or a commitment to construction? Since a site will not be finalized until January, 1989, why should Congress appropriate any construction money prior to that time?

Answer: There will be no physical construction at the site until after the Record of Decision which is presently scheduled for January 1989.

As I explained earlier, the appropriation of construction funding is important to establish approval from the Congress to enable the Department to proceed with essential FY 1988 activities such as site selection, detailed design, and long lead procurements.

Question: Why is only $35 million needed for FY 1988?

Answer: The SSC research and development program has been carried on at $20 million per year since FY 1984. As stated earlier, the FY 1988 request includes $10 million for construction and $25 million (an increase of $5 million over previous years) which is considered to be the minimum needed to continue the SSC research and development. The President's decision on proceeding with the SSC was made after the State of the Union message. With this timing it was necessary to provide funding for SSC from within the high energy physics total of $566 million. The choice of $35 million was a compromise to allow a reasonable collection of high priority SSC activities and to allow strong support for other parts of the high energy physics program, especially the high priority operation of the new facilities at Fermilab and SLAC.

Question: When the President approved this major science initiative was it understood that the budget constraints would compel the shutdown of other newly completed accelerators and improvements at accelerators?

Answer: There was no intention that other high energy physics facilities would have to be shutdown prematurely. On the contrary, the FY 1988 budget provides for operation of the high energy physics facilities with high priority given to reasonable utilization of the new Tevatron and Stanford Linear Collider facilities. It is important to point out that with the initiation of SSC in FY 1988 it will be almost ten years before it will be completed and ready to carry out a forefront research program. As SSC nears operational status, existing facilities which are no longer operating at the research frontier will be shutdown to permit manpower and funding resources to be directed toward the most forefront research.

Funding for the SSC in FY 1989 and beyond will require incremental funding above the present base activities. The Department also intends to seek maximum cost-sharing funding from other countries as well as private industry, and state and local governments.

Question: Or, in fact, will there be any shutdowns or less use of the existing facilities, particularly the new facilities which have just been completed, such as at Stanford and at Fermi lab.--the new collider as well as the operation to the older upgraded colliders. Can all of these facilities be operated during FY 1987 and FY 1988 at a reasonable level of use?

Answer: Two major upgrades of U.S. facilities, the Stanford Linear Collider (SLC) and the Fermilab Tevatron Collider, are beginning operation in FY 1987 and will be operated at a reasonable level in FY 1988 with the President's budget request. These are world forefront facilities and their operation is being given highest priority in the U.S. programs. The Brookhaven Alternating Gradient Synchrotron will be operating at a constant level and the SPEAR and PEP colliders can be brought back into operation at moderate utilization levels in FY 1988 with the funding requested in the President's budget request.

The substantial reductions from the President's budget request for FY 1987 did indeed cause disruptions in operations of the high energy physics facilities in FY 1987. Highest priority was given to reasonable operation of the Tevatron and to completing and bringing into operation the SLC, with some operation for research at the end of the fiscal year. There will be no FY 1987 operation of SPEAR or PEP for high energy physics at the Stanford Linear Accelerator Center (SLAC), and operation of the Alternating Gradient Synchrotron (AGS) will be at a relatively low level.

Question: The SSC is explained as being a research tool designed to answer many unanswered questions that cannot be addressed by any facility in the world, either in operation or under construction, and it is expected that it will have significant research results and technological spinoffs and innovations that will profoundly touch every human being. Can you give us some inkling of a few concepts that would give us more confidence that this would be the case?

Answer: The super collider is a critical step in the search for the fundamental nature of matter and energy. Basic science has always led to discoveries and innovations that profoundly affect our lives and we expect to continue to have a high return on investments in research. The present understanding of matter and energy at its most elementary level is quite successful in describing known phenomena and observations. This success raises even more questions, however, and finding the answers to these questions will change our view and understanding of the physical world and no doubt ultimately lead to a better ability to control nature and apply it to our benefit. Some specific questions that will be addressed by the SSC: What is the origin of mass? Do all forces stem from a single unified force? Are there new energy sources? Having gone from atoms to nuclei to protons to quarks, what is inside the quarks? Are there new types of undiscovered forces and matter in nature?

Basic science has always led to discoveries and innovations that profoundly affect our lives. Advances in basic knowledge contribute to economic and technological competitiveness through applications of the new knowledge and discoveries and through spinoffs. New concepts arising from high energy physics also have profoundly altered the course of many other sciences. High energy physics interacts with other areas of physics such as astrophysics, nuclear physics, atomic physics and condensed-matter physics. Achievements in accelerator research in high energy physics have enriched several fields of science. Some specific applications include: advanced electron microscopes, accelerators that allow us to see materials at the atomic level; synchrotron light sources and high-intensity neutron sources to study materials and biological molecules; and accelerator mass spectrometers to determine the age of samples from the earth's crust. High energy physics requires the use and development of the most advanced technologies.

Frontier science stimulates frontier technology. There are numerous instances of the impact of applications of technology flowing from high energy physics in the areas of nuclear medicine, computer chips, superconductivity, cryogenics, etc. Even though it is not possible to predict precisely when or where the application will occur, I am firmly convinced, based on the excellent track record of the field, that future applications will be as numerous and profound as those from past research. For example, approximately 100 million Americans each year receive diagnostic or therapeutic benefits from nuclear medicine applications. One example is the PETT scan (Positron Emission Transaxial Tomography), a novel technique for directly studying the function of organs such as the brain. When the positron particle was discovered in the 1930's, many viewed it as an abstract curiosity of physicists. Today this abstract discovery provides the basis for an important tool of medical research and diagnosis. Who would have been able to identify this application when the positron was discovered 50 years ago. Today's quark is the positron of the 1930's.

Question: Dr. Trivelpiece, I understand that the siting criteria will not be announced until later this spring. Do you believe that there will be sufficient time for States to submit their proposal with the present deadline occurring in August?

Answer: Yes, I do believe that the time allowed is adequate. The information required of the proposers can, to a large extent, be based on readily available data. We are not requiring, in support of proposals, costly and time consuming environmental and geological investigations. Those proposers that are recommended on the Best Qualified List from the National Academies of Science and Engineering will be asked for such additional data later in the selection process.

As you know, a complete and thorough design for the SSC has been prepared so that proposers will not be asked, nor are they expected, to provide any engineering or design data for the facility itself. In consideration of the aforementioned, we believe that the time allowed for preparation of site proposals is sufficient.

Question: How will you ensure an open and competitive site selection process? I already hear rumblings that in such a short time frame, that it will be impossible to ensure fair and equitable treatment for all prospective sites. How do you respond to this when raised?

Answer: The SSC site selection process has been carefully formulated to insure that the Government site requirements and evaluation criteria will be clearly articulated and that a credible, multi-stage evaluation procedure is employed to review proposals. The National Academy of Sciences/National Academy of Engineering (NAS/NAE) will carry out a major portion of the site selection process. They are well known for their fairness and lack of bias. We are confident that this will lead to the selection of the site best suited to meet the Government's needs.

Question: Can you shed any light at this time on the process to be followed by the Department in evaluating the sites to be referred to the National Academy?

Answer: Site proposals received by the DOE will be screened against a limited number of qualification criteria which will be identified in the Invitation for Site Proposals. Those meeting minimum requirements will be referred to the National Academy of Sciences/National Academy of Engineering for further evaluation.

Question: How much money is being spent in the current fiscal year on SSC work directly and indirectly? What impact has this had on other high energy physics activities or facilities?

Answer: In FY 1987, $20 million is being spent on R&D specifically related to SSC. An additional $5 million being spent on R&D of a generic nature will have some benefits for SSC. These R&D programs are at the same dollar level as in FY 1986.

Question: What are the principal problems likely to be encountered if Congress decides to proceed with the construction of the supercollider? Are we reasonably confident that we have the necessary magnet technology in hand (there will be over 10,000 superconducting magnets needed for the SSC. I understand we have no qualified U.S. manufacturer at this time).

Answer: The technical feasibility of the SSC has been clearly demonstrated. A detailed Conceptual Design Report was completed and issued in March 1986, and carefully reviewed subsequently by the Department. The design of the superconducting magnets has evolved from that successfully used at Fermilab for the Tevatron. Further development is underway to optimize and finalize the design. A program involving industry in the magnet R&D is planned in the near future so as to lead to qualification of manufacturers prior to the start of full-scale magnet production.

Question: Dr. Trivelpiece, in the upcoming budget debate, either this year or next year, the Congress will be faced with two major scientific initiatives in the non-defense area--the $13 to $15 billion space station and the $8 to $10 billion super conducting super collider. If forced to choose because of budgetary limitations, which would you advise the Congress to proceed with and why? Is there better science and technological spinoffs more likely to come from the SSC--why?

Answer: I'll do my best to respond, Senator, although I'm sure you recognize that I am far less knowledgeable about the space station than about the supercollider.

As indicated in the budget documents given the Congress, the present projected SSC costs show a total of $5.32 billion in then year dollars, including construction, R&D, detectors, and preoperating funds. We believe this estimate to be accurate to within 10 percent. Until site selection and additional design studies are completed, this estimate cannot be improved. This figure does not take into account anticipated international, state, local, and industrial contributions.

I consider both the SSC and the space station to be very important to this country, and I must strongly endorse both of them. They have very attractive features in common: frontier science; advanced technology; and as major symbols of America's ability, prestige and commitment to the future.

Their relative scientific merit is difficult to compare and necessarily speculative. I think most of us can more readily imagine the likely tangible benefits of the space station. I believe it is widely considered a major step towards a manned mission to Mars, which has been urged by some for a number of years now. I think that the public's image of mankind's long term future in space, as portrayed in very popular motion pictures and television programs, makes it much easier for us to visualize and relate to the activities that a space station would make possible. The practicality and usefulness of the project, and the next steps it may facilitate, are relatively easy to imagine.

The supercollider, on the other hand, represents a search for a less tangible but much more basic commodity - new knowledge and understanding of matter and energy on the most fundamental level. To appreciate the importance to society of fundamental new information, we must be reminded of the enormous benefit and widespread application of earlier great research discoveries such as electro-magnetism, relativity, and nuclear processes. From that point of view, it is strikingly obvious that new knowledge of how nature behaves translates, increasingly quickly these days, into new ways of controlling natural phenomena to great benefit for society.

In terms of better science and technological spinoff, I think there are qualitative differences between the space station and the supercollider. I would not characterize supercollider physics as better than the scientific advances the space station may provide, but I think most scientists would agree that it is more fundamental. As such, the potential for technological spinoffs is probably greater over the long haul, but also much more difficult to characterize since new discoveries and future new knowledge are, by definition, not knowledgeable.

Question: On the CEBAF project for which $33-1/2 million is requested to continue construction, we have a commitment to see that through. That being the case, why don't we proceed with its construction at an optimum pace, so as to avoid the cost growth and other penalties incurred by stretching it out? I understand that it was originally scheduled to receive about $60 million. What is the best capability we have in FY 1988 to proceed with CEBAF construction. I assume it is less than the $60 million once discussed. Can $40, $45 or $50 million by effectively and efficiently used?

Answer: The funds requested for CEBAF construction in FY 1988 represent a carefully considered balance between continuation of the nuclear physics research program and the requirement to construct CEBAF as expeditiously and effectively as possible. The requested funding also takes into account the total program balance in ER and DOE within available resources. CEBAF, like many other projects, would be able to utilize increased construction funding. Up to $50 million in FY 1988 could be effectively used to maintain total costs and reduce the construction period by 6 months if the outyear funding remains commensurate.

Question: If you had more budget allocation in FY 1988, where would you apply the extra dollars?

Answer: I believe our FY 1988 request is adequate to allow planned progress in each of the programs in the Office of Energy Research. While nearly every research program could benefit from increased budgets, it is my view that the funding is adequate particularly in view of the national need to bring massive Federal deficits under control. Therefore, I would prefer not to speculate concerning additional budget resources.

Question: What mortgages do we have from prior budgets or this budget for future fiscal years--in other words, how full is our platter and what are we committed to? Let's go down the list starting with the National Labs, Argonne, Brookhaven, FERMI lab, Stanford, Oak Ridge, Lawrence Berkeley, and so forth. What I want to know, is, what major facilities have we got to deal with? What new starts are we making? What room do we have for new initiatives? What downpayments are we making to major new machines or accelerators?

Answer: To keep the programs in basic research at the leading frontier of science requires investments in large new facilities which can be used by scientists from the national laboratories, universities, and industry. The DOE national laboratories must retain the capability to pursue avenues of scientific advancement. In this regard, last year I instituted a "Scientific Facilities Upgrade" program to assure that the laboratories remain preeminent in certain key fields of research. This upgrade includes four facilities that have been identified by the scientific community as being the most critical to the future needs of the Department's basic research programs. The four facilities are: a 1-2 GeV Synchrotron Radiation Source - LBL, a 6GeV Synchrotron Radiation Source - ANL, an Advanced Neutron Source - ORNL, and a Relativistic Heavy Ion Collider - BNL. A second year of construction funds for the 1-2 GeV machine are included in the FY 1988 budget. The remaining three facilities are being supported with research and development funds to define their scope, schedule and cost and they will be proposed for construction after the necessary preconstruction R&D is completed to resolve technical issues.

In addition to the above projects, my office is also supporting the continued construction of the Continuous Electron Beam Accelerator Facility and we are proposing to initiate construction of the Compact Ignition Tokamak Project at Princeton and the Superconducting Super Collider (SSC). When viewed as a whole, the cost to construct these projects is large, however, this is an investment essential to the nation's future. These projects are supported by the scientific community and have been reviewed by prestigious advisory panels and other ad hoc groups. The advances that will be made in science with these facilities, while unknown at this time, will surely occur. Each project will enable the pursuit of new science and will insure the vitality of the national laboratories and the attendant interactions which occur with universities. The above projects reflect the Administration's strong commitment to advance basic scientific research in recognition of its role in maintaining the nation's economic competitive position.

Question: From what sources of funding other than DOE do users of the accelerators receive their funds? Is there any non-government money used for operations and experiments or users groups? Are most of the groups that use DOE facilities from universities in this country? Do we have any statistics as to the breakdown by groups, domestic or foreign, academic or commercial enterprises, etc.

Answer: For the High Energy Physics program non-DOE funding of users is obtained from university contributions, NSF funding of user groups, and funding of foreign users doing experiments at U.S. accelerators by their own governments. The users of the Basic Energy Sciences Program accelerators and facilities receive their funds from Federal agencies such as the Departments of Commerce, Defense, Health and Human Resources, and the National Science Foundation; from a large number of industrial companies such as IBM, General Electric, Mobil, Exxon, AT&T, etc.; and the university researchers receive some support from their home universities either state or private. For the Nuclear Physics programs the other major source of Federal funds for university users of DOE accelerator facilities is the National Science Foundation, which provides nearly as much support for this class of users as does DOE. In addition to this Federal funding, the universities themselves provide significant contributions to the support of these user programs in the form of faculty release time, use of computer and shop facilities, and partial funding for instrumentation projects.

In the High Energy Physics program, no non-government money is used for support of accelerator operations. Most U.S. user groups are funded partially by their home institutions and foreign users are funded by their governments. For the Basic Energy Sciences program industry supports their own researchers which make up approximately 20-25 percent of the total users of Basic Energy Sciences facilities. The operations of the facilities are entirely paid for by the Department of Energy except for proprietary research paid by industry which only constitutes a tiny portion of the total use. In the Nuclear Physics program, when beam time at an accelerator is allocated to a user by a program committee on the basis of scientific merit, the user is not charged for any accelerator operations costs. Beam time is also provided at no cost to the user for certain categories of use specified in agreements, such as the weapons and materials research using WNR/PSR at LAMPF and the biomedical research at the LBL Bevelac. Other types of users, primarily commercial, pay for accelerator operations costs when they do not fit either of the above two categories.

For support of the associated research costs, in addition to the university support mentioned above, there are some instances of very substantial outside support, such as the $500,000 provided annually by the State of Tennessee for operation of the Joint Institute for Heavy Ion Research in support of outside users of HHIRF at ORNL.

In the High Energy Physics and Basic Energy Sciences programs, by far most of the U.S. groups that do experiments at DOE facilities are from universities in this country. There are some foreign user groups. In the Nuclear Physics program, the breakdown of user types varies somewhat for the various accelerators, but for the DOE Nuclear Physics user facilities more than 50 percent of the users are from universities, about 45 percent from government laboratories, and less than 5 percent from other institutions (including industry). Foreign participation averages about 15 percent of the total, but varies considerably from year to year.

There are some statistical estimates that can be made as to the breakdown by groups in high energy physics. U.S. groups perform over 80 percent of the total experimental effort at DOE facilities. Of the U.S. users, university users account for about 80 percent and laboratory-based groups for the remainder. Roughly one-fourth of the U.S. university groups are supported by the NSF and three-fourths by DOE. Foreign user groups make up somewhat less than 20 percent of the total user population at U.S. facilities. Likewise, U.S. user groups make use of unique foreign facilities. No commercial enterprises are involved in high energy physics experiments. In Nuclear Physics, the breakdown of user types varies somewhat for the various accelerators, but for the DOE Nuclear Physics user facilities more than 50 percent of the users are from universities, about 45 percent from government laboratories, and less than 5 percent from other institutions (including industry). Foreign participation averages about 15 percent of the total, but varies considerably from year to year. For Basic Energy Sciences program facilities, about 50 percent of the users are from universities, about 30 percent from government laboratories and 20 percent from industry. Of the total number of users, the overwhelming majority are U.S. citizens. The foreign participation will vary greatly from year to year, but averages about 15 percent.

Question: What percent of the total dollars involved in the user facilities come from DOE? From NSF? Where else do the funds come from?

Answer: One hundred percent of the funding for operating the Brookhaven National Laboratory Alternating Gradient Synchrotron (AGS); the Stanford Linear Accelerator Center (SLAC) with its Linac, and the SLC, PEP, and SPEAR colliders; and the Fermi National Accelerator Laboratory's Tevatron comes from the Department of Energy. All of the funds for operation of Cornell University's CESR facility come from the NSF. As indicated earlier, funding for the university-based user community comes from a variety of sources. DOE provides about three-fourths of the Federal funding of user groups. DOE provides over 90 percent of the total Federal support of high energy physics with the remainder for NSF.

For the Nuclear Physics facilities, accelerator operations for the user programs are 100 percent funded by DOE. The research activities are supported through or by the individual research groups that carry out the experiments at each facility. DOE supports about 60 percent of the research, NSF about 25 percent, foreign institutions about 10 percent, and 5 percent from other Federal agencies and industry.

For the Basic Energy Sciences facilities, the operating budgets are totally supported by DOE except for a tiny amount (less than 1 percent) paid by industry for proprietary research. The research budgets are carried by the various organizations which support the particular research underway at each facility. The DOE supports about 60 percent of the research, NSF about 10 percent, other Federal agencies about 10 percent and industry about 20 percent.

Question: Recent news articles report a dramatic breakthrough in the race for the super computer. I understand it involves a new class of super conducting material. Can you give us a brief lesson about this? What's it all about?

Answer: The emergence of this new class of superconductors, comprising various materials with chemical compositions and structures based on the lanthanum copper oxide system, has been an exciting development both for its interest in basic science and for the prospects offered for revolutionary advances in technological applications. Superconducting materials carry electric currents with no resistive losses. Until recently all known superconducting materials exhibited this zero-resistance property only at such very low temperatures (more than 400 degrees below zero Fahrenheit) that their practical use has been limited to certain special applications. In 1986, however, IBM researchers in Zurich, Switzerland discovered superconductivity at a significantly higher temperature in a mixed oxide lanthanum, barium and copper, and this development in this new class of materials led to a series of closely spaced discoveries at still higher temperatures by scientists at many laboratories around the world, including our major DOE laboratories. The DOE laboratories have been working together closely, having held several meetings to report and coordinate research activities and have discovered several new compounds of the high temperature variety. At present, these new materials must also be refrigerated, but several are now known to be superconducting at about -280 degrees Fahrenheit, a temperature readily achievable by using the common and inexpensive coolant liquid nitrogen. Although this opens up possibilities for a great number of practical applications, there is still much work to be done at both basic and developmental levels before benefits in such applications can be realized. Observing an effect in a small laboratory sample is one thing, but moving up to large scale production of usable material is something else. It could well be several years before any appreciable impact from these discoveries is felt in the everyday world. Certainly, one of the very attractive areas for future applications is in the development of new advanced computers with components made out of superconducting materials, to increase the speed of processing steps. There are numerous other areas, incidentally, for which prospects for applications are also very exciting. These include zero-loss transmission of electricity over long distances, for example, as well as the development of new high-field zero-loss magnets for industrial use, scientific research and in medical diagnostics. Here again, however, one can hardly expect to see benefits realized in the very near future.

Question: There are several items in the FY 1988 budget request in the materials sciences applied math sciences and energy biosciences areas where commitments are being made that will lead to construction of major new scientific facilities. I refer to the synchrotron radiation source at Berkeley, the synchrotron at Argonne, the advanced neutron source at Oak Ridge, among others. Briefly review each of these items, the estimated cost, the amount in this year's budget, a funding profile, the purpose, need and expected contribution.

Answer: The FY 1988 budget request has several items in the Basic Energy Sciences program as part of the Department of Energy's Advanced Scientific Facilities Initiative. They are all located in the Materials Sciences subprogram area. These are the 1-2 GeV Synchrotron Radiation Source which is under construction at Lawrence Berkeley Laboratory, the 6-7 GeV Synchrotron Radiation Source under development at Argonne National Laboratory, and the Advanced Neutron Source under development at Oak Ridge National Laboratory.

The estimated cost of the 1-2 GeV Synchrotron is $98.7 million. The 1-2 GeV Synchrotron began construction in FY 1987 with $1.5 million in construction funds, and the funding request for FY 1988 is $18 million. The expected initial operation date is 1992. The purpose of the 1-2 GeV Synchrotron is to generate ultraviolet and soft x-ray light with high brilliance and in very short pulses for studies in materials and surface science, atomic and molecular physics, chemistry, and biology. The need for funds by the Department of Energy is for the total construction cost of the facility; however, funds for some instrumentation of the many beam lines are expected to be contributed by participating research teams from industry, universities, and other federal agencies.

The estimated cost of the 6-7 GeV Synchrotron is yet to be determined; however, it is expected to be about $385 million. Preconstruction R&D is currently underway on this project to refine technical issues, scope, schedule, and costs. For FY 1988, $5.5 million of preconstruction R&D is being requested, and construction would take about 5 years. Federal funding would be needed for the total construction cost; however, some instruments for the beam lines are expected to be provided by participating research teams from industry, universities, and other government agencies. The purpose of this facility is to provide x-ray light for scattering experiments to determine the bulk structure of matter, x-ray spectroscopy to characterize materials, and to study changes in the properties of matter as a function of time. This source will be especially useful for complex materials such as polymers and biological materials.

The Advanced Neutron Source consists of a steady state reactor designed to produce high fluxes of neutrons. The estimated cost is yet to be determined; however, it is expected to be about $300 million, and take about 6 years to construct. Preconstruction R&D is currently underway to refine technical issues, scope, and the cost. In FY 1988, $3 million is requested for preconstruction R&D. The need for funds would be for the total construction cost; however, as with the synchrotrons, participating research teams would be expected to provide funds for some beam line instrumentation. The purpose of the neutron facility is for neutron scattering experiments to determine the bulk structure of matter especially in areas such as magnetic structure and for light atoms where x-rays are not appropriate, for the production of isotopes for research, industrial, and medical uses, and for radiation damage studies.

There are no items in the applied math sciences or energy biosciences areas in the FY 1988 budget request which would lead to construction of major new scientific facilities.

Question: The budget includes a new class-7 computer to be located at the National Magnetic Fusion Energy Computational Center. What is the justification for this major investment?

Answer: Research at the forefront of science and technology as done within the Office of Energy Research (ER) demands adequate access to supercomputer power. This fact has been verified in several ways. First, the report, 'The Role of Supercomputers in Energy Research Programs,' published in February 1985, identified and documented many important research areas throughout ER which require advanced supercomputing resources. Second, this need for supercomputing resources has been verified by the high demand for these resources by researchers in all ER programs. The high demand is exhibited through proposals for resources submitted to ER headquarters from the ER research community. The following table summarizes the large growth rate of this demand versus availability for supercomputing resources for the non-fusion ER programs:

	FY 84	FY 85	FY 86	FY 87
Hours Requested	10,400	24,080	45,060	69,151
Hours Available	800	12,000	24,000	24,000

Although careful judgement has been used to allocate supercomputer resources to only the most important problem areas, ER researchers have completely utilized all resources available to them. Furthermore, the requirement for supercomputing is growing at a very high annual percentage. At current growth rates, this ER access program will be able to address less than ten percent of the ER supercomputing requirement within the next three years.

Another way that this requirement has been verified is through the benefits to the ER programs that supercomputing has made in a very short time. Significant accomplishments have been made in all program areas. In High Energy Physics, researchers have been able to realistically model Klystrons (a device for accelerating electrons) for the first time. In Materials Science, researchers have been investigating new superconducting materials. In Applied Math, researchers have developed new algorithms for supercomputers to solve ER computational problems, e.g., an algorithm to address the high energy particle track finding problem in HEP and which operates orders of magnitude faster than scalar algorithms. In the Biological and Environmental Research program, supercomputers are being used to complete structure analysis of complex macromolecules, i.e. DNA.

More importantly, many difficult problems cannot even be undertaken using current supercomputer systems. The amount of complexity incorporated in computational models is often scaled down to meet the existing systems capabilities. Additional supercomputer capability is needed to incorporate more dimensions, finer resolutions, more physics and longer time scales into ER computations. The real world exists in three space dimensions plus time, however, current systems for the most part can only treat ER computations of two dimensions plus time. In accelerator physics, magnet quality and alignment tolerance computations require much longer time scales to correctly simulate misalignment and fabrication errors and to estimate their influence on beam quality at the interaction point. In materials science, a critical input for solidification computations is the interparticle interaction potential and accurate simulation of such potentials depends upon several thermodynamic state variables or physical effects, i.e., density, temperature, pressure. The coupled complexities of these physical effects of size and interaction potential computations are prohibitive on current systems. Therefore, the most advanced and capable systems available will be needed to support the ER supercomputer requirement. In particular, a Class VII system will be needed in FY 1988.

To summarize, this supercomputer requirement has been validated through good usage and through documented accomplishments, this requirement is growing rapidly, and the capability provided by a Class VII system is needed to undertake investigation of those research areas that we cannot adequately address today.

Question: What is the status of the Center for Advanced Materials project at Lawrence Berkeley?

Answer: The Center for Advanced Materials (CAM) at Lawrence Berkeley Laboratory (LBL), established in FY 1984, consists of two laboratories: Surface Science and Catalysis Laboratory and the Advanced Materials Laboratory, both of which are under construction. The Surface Science and Catalysis Laboratory is expected to be completed for beneficial occupancy by summer of 1987. The Advanced Materials Laboratory should be completed by the end of 1988. Construction funding requirements will be completed with the FY 1988 request. Concurrent with the construction, workshops with industrial participation have been held and the major research areas identified and initiated in polymers, ceramics, light alloys, catalysis, semiconductor materials, instrumentation, structural alloys and ceramic-metal interfaces. The interactions with industry are increasing. Four industrial fellows have been attracted to CAM: one from Exxon Research and Engineering Company to work with the Advanced Instrumentation for Surface Science Program, one from Catalytica Associates, Inc. to work with the Catalysis Program, one from Union Carbide to work with the Polymers and Polymer Composites Program, and one from Intel to work with the Ceramic Interfaces Program. Industries have already provided about $600,000 of support for graduate students and postdoctoral appointees. In addition, there are ongoing collaborative research efforts with many companies, including Dow Chemical, Chevron Research Company, Ashland Chemical Company, Union Carbide, W. R. Grace, and Mobil Research and Development Company.

Question: Would you briefly review where we are in the magnetic fusion program and the plan proposed for the program for the next few years? What is the goal and where are we going with this program?

Answer: The goal of the Magnetic Fusion program is to establish the scientific and technological base required for fusion energy. The Magnetic Fusion Program Plan, that was developed in 1985, lays out the steps required for successful development of fusion energy. This Plan is currently being implemented by the program. The long-term prospects for the development of fusion are excellent. Upon reviewing the progress of the program, the Energy Research Advisory Board's Technical Panel recently concluded that "fusion energy continues to be an attractive energy source of great potential for the future, and that the Magnetic Fusion Energy program continues to make substantial progress towards the development of fusion energy." The most visible example of this progress is the TFTR results where ion temperatures of 250 million degrees have been attained. In the burning plasma area, TFTR has achieved conditions in deuterium plasmas within a factor of four of those required for equivalent energy breakeven and is expected to reach breakeven conditions, using deuterium only, in FY 1988 and to demonstrate breakeven in deuterium-tritium plasmas in 1990. Progress has also been made in investigating the scientific issues which will lead to improved reactor conditions on Doublet III-D device at GA Technologies, PBX at PPPL, Advanced Toroidal Facility at ORNL, and the Reversed Field Pinch at LANL.

In the technology areas, research in such areas as materials research has led to increased confidence of vanadium as a candidate material for reducing activation in the fusion device.

These are just a few of the recent accomplishments in the fusion program.

Question: How much will the Compact Ignition Tokamak cost? Why do we need to proceed with this experiment now? I understand that it will be built at Princeton where the large Tokamak Fusion Test Reactor is located. How much of this fusion budget goes to Princeton? What is the useful life of the large Princeton tokamak? What would be done with that facility?

Answer: The CIT construction project total estimated cost is $357M. This includes the design, procurement, fabrication, and installation of the new CIT device and systems and the required CIT modifications of the existing TFTR equipment and facilities. The construction project is planned to be accomplished in FY 1988 through FY 1993. During this period, there will be related CIT costs for experimental diagnostics - $29.8M; supporting technology R&D - $28.5M; and other general support items - $29.2M.

Understanding the properties of burning plasmas is one of the four key technical issues of the U.S. Magnetic Fusion Program Plan. The CIT's objectives of achieving plasma ignition and short pulse burn are the next logical steps in the fusion program. Progress on TFTR and other devices has made it technically feasible and appropriate to proceed with an ignition experiment at this time. The European and Japanese fusion program leaders acknowledge that the CIT will furnish vital information for the successful operation of the major next step in the world's fusion program, an Engineering Test Reactor. Decisions on this facility are presently scheduled for about the time CIT operates. It is also important to complete CIT expeditiously in order to maintain the vitality and international competitiveness of the U.S. program.

The CIT will be built at PPPL and will make extensive use of the past investment in TFTR facilities, equipment, and personnel resources. Low cost has been a major objective of CIT because of limited U.S. Fusion Program budgets, and, therefore, making maximum use of previous investments is part of the CIT project strategy.

In FY 1988, $102.1M out of a total fusion program request of $345.6M is projected to go to Princeton. The $102.1M includes construction funds for the CIT project totaling $8M, part of which will be spent outside of Princeton.

The present research plan is to operate TFTR through FY 1990. The remaining experimental work on TFTR is aimed at achieving equivalent breakeven in deuterium plasmas, finding the optimum method for achieving actual breakeven in deuterium-tritium plasmas, and carrying out a series of breakeven experiments in FY 1990. Following these experiments, the TFTR tokamak core will be allowed to cool for several years and then will be decommissioned. Most of the auxiliary TFTR facilities will be maintained for use in the CIT project. This reuse of existing facilities will substantially reduce the cost of the CIT project.

Question: I understand the CIT compact ignition tokamak is an interim step before proceeding with an Engineering Test Reactor (ETR). Where do we stand with this ETR project, and what is the plan for its construction?

Answer: The U.S. proposed that the U.S., Japan, Europe, and the Soviet Union join together to begin conceptual design of an Engineering Test Reactor (ETR) and also begin research and development work that is critical to validating the design. Delegations from these four parties met in Vienna on March 15 and 16, 1987, under the auspices of the International Atomic Energy Agency (IAEA) to discuss this proposal. The parties reached an understanding that the proposal is a sound basis for further discussion. They also agreed to appoint representatives to develop a common set of detailed technical objectives for the conceptual design and the organizational arrangements to implement the proposal. Each party has an ETR study in progress. The U.S. study is led by the Lawrence Livermore National Laboratory (LLNL) and includes participation by several laboratories, industrial contractors, and universities. The purpose of the present U.S. study is to prepare for the proposed international conceptual design work.

At present there is no plan for construction of the ETR. A decision to initiate construction would not come until after completion of the conceptual design report in 1990. The purpose of the conceptual design effort is to allow cost estimates and time schedules for the facility construction to be developed. Whether or not construction would be initiated, either by the U.S. or with one or more international partners, is a subject that will be considered by the U.S. and each of the other participating governments after 1990.

Question: Where will the ETR be located? I visited the Doublet experiment at GA Technology last summer. I understand the Japanese collaborate with us in this area of fusion technology. Do we have the funds included in this budget to live up to our agreement with the Japanese? Are the Japanese building a fusion facility in Japan? Are we putting any money into it? Are the Japanese expressing interest in sharing the cost of the CIT project?

Answer: There has not been a site selected for an ETR, and we again note that there has not been a commitment by the U.S. or any other fusion program to build an ETR device.

The Japanese provided funds for part of the DIII-D fabrication and maintain a team of scientists at GA to participate in the experimental program. The FY 1988 budget request contains sufficient funds at GA and LLNL (which also collaborates on the DIII-D experiments) to carry out a research program using long pulse neutral beams and ECH heating which meets our commitment to the Japanese. The Japanese have recently completed the JT-60 tokamak, which is slightly larger than the TFTR tokamak and includes advanced design features, more extensive support facilities, and more capable heating systems. They are also designing a version of an engineering test reactor. At the present time, we carry out scientific information and personnel exchanges with the Japanese on both of these activities, but we do not provide any direct funding to Japan.

The Japanese have not expressed an interest in sharing the cost of CIT. They have heavy funding commitments to conduct the JT-60 experimental program and to support other new or planned facilities in Japan. They have expressed an interest in participating in the project through contributions of diagnostic equipment and personnel.

Question: I understand that there are funds in this budget that will support a U.S. design team that will begin work on a design of an international ETR including R&D. How much money is included and where will this work be performed? What are our commitments to an international ETR? What is the total estimated cost of an international ETR?

Answer: The FY 1988 budget request for ETR is for $8M for conceptual design plus $8M for validating R&D, for a total request of $16M. The total amount of funding required for the three year FY 1988 - FY 1990 period is estimated to be $56M, made up of $24M of design plus $32M of R&D. The U.S. ETR design team will be led by LLNL. The team will include the Fusion Engineering Design Center (FEDC), Argonne National Laboratory (ANL), Oak Ridge National Laboratory (ORNL), the University of Wisconsin, the University of California at Los Angeles (UCLA), Rensselaer Polytechnic Institute, and the Princeton Plasma Physics Laboratory (PPPL). Participation by several industrial contractors is also anticipated. The work will be done by these institutions at their home facilities with regular meetings and workshops under LLNL coordination and with extensive use of modern telecommunication techniques.

The U.S. has proposed a three-year conceptual design and validating R&D program. Should this proposal be accepted by the international partners, the U.S. fusion program would believe itself committed to complete the conceptual design and validating R&D program. Each of the four parties is expected to participate equally. Completion of the three-year conceptual design and validating R&D program would not commit the U.S. to construction of the reactor. We are unable to provide a cost or schedule estimate for the construction project until the conceptual design report is completed in 1990.

Question: The biological and environmental research program; (the high energy physicists) have their SSC initiative. Scientists involved in modern structural biology have an initiative that could lead to a multi-billion dollar program similar to the SSC. The Phase I of this project has already been completed. It is my understanding that this program referred to as the human genome could cost several billion dollars to complete. Would you briefly review where we are and what this program is about? How much money is in the budget, where does it lead us, and what is the purpose?

Answer: The project for mapping and decoding the human genome is indeed massive in the amount of data that will be gathered and processed. However it can be developed gradually, as improvements in the technical base required to pursue the project efficaciously and economically are achieved.

In brief, the goals of the Human Genome activity are to create the technologies and resources which will make it possible to efficiently acquire a complete and detailed understanding of human biology and inheritance at the molecular level. More specifically, the goals of the first several years of the project are: 1) to prepare a physical map of the human genome, i.e., a complete set of ordered DNA fragments covering the entire genome which will be stored in and distributed through a central repository; 2) to develop innovative new approaches to increase the rate of DNA sequencing by orders of magnitude; 3) to develop the computer database, analytical and networking resources which will facilitate the storage, retrieval, analysis and dissemination of cloning, mapping, and sequence information (including cross-references to other relevant databases). Decisions regarding a large-scale sequencing effort would be deferred until new, more efficient sequencing technologies can be evaluated. This will ensure that we do not inadvertently commit to a multibillion dollar project.

The human genome mapping activity is a large scientific challenge. Successful and efficient accomplishment of the goals of the program will require a coordinated, multidisciplinary effort involving universities, national laboratories and industry, and other countries, perhaps. We will need to bring together technologies from the fields of biology, computing science, materials science, instrumentation, robotics, physics and chemistry. With the guidance of our advisory committee, we envision the establishment of several "minicenters" which will focus on one or more aspects of the program. Centers for the preparation of physical maps of specific human chromosomes, and development of relevant technology, have been established at Columbia University and the Los Alamos and Lawrence Livermore National Laboratories. Each of these involves extensive collaboration with other institutions and scientists. Industry contracts will be used when available and where appropriate.

The Lawrence Livermore National Laboratory and the Los Alamos National Laboratory have been engaged in related work for several years, particularly in the National Laboratory Gene Library Project. This project has been preparing human chromosome specific DNA libraries. The first phase of this project is completed and storage and distribution of these libraries has been supported by the Division of Research Resources of the National Institutes of Health. The human genome project is a logical successor to the Gene Library Project.

It is important to stress that the actual cost of the Human Genome activity will be very sensitive to the state-of-the-art technologies associated with DNA sequencing, and the related requirements for automation of procedures for cloning, mapping, data handling and data analysis. As an example, compare the current and projected future costs for DNA sequencing and their corresponding implications for sequencing the human genome. The current cost for determining the DNA sequence of a human genome is $1/base or $3 billion. However, the Japanese are rapidly constructing sequencing instruments that will do the job at an estimated cost of $0.17/base or $510 million and experts in this country anticipate automated instrumentation in the near future that could do the sequencing for as little as $0.01/base or $30 million.

These figures illustrate the importance of making substantial initial investments in technology. That is why our approach to sequencing the genome is staged as mentioned above. The FY 1988 budget includes $11.5 million directed toward initial activities of this project. At the end of the initial five years if the speed, error rate, and cost are appropriate, then an organized and coordinated effort to sequence the entire genome could begin.

Solar and Renewable Energy

Question: What is the highest priority research activity in the solar energy program in terms of technologies with the greatest promise for contribution to the nation's energy supply mix?

Answer: Each of the solar energy technologies proposed for funding exhibits promise for economic viability in the future. Each of these technologies embodies a number of attractive economic, technical, or environmental features if research proves successful in overcoming the remaining scientific or technical obstacles. The FY 1988 request would maintain a balanced program among these technologies while focussing on only the highest priority research necessary to establish their viability. The type of program proposed for FY 1988 will sustain momentum toward providing the private sector with a range of technology options while relying upon industry to select the winners as it elects to undertake the risks of the technology development and deployment.

Question: What are the present goals for improvements in the photovoltaic work?

Answer: The present goal for photovoltaics research is 6¢/kWh. This goal requires a reduction in module cost to less than $100 per square meter, an increase in module efficiency to almost 20% and an increase in system lifetime to 30 years. The strategy to achieving these improvements is keyed to advances in three principal material areas--amorphous and crystalline silicon, advanced polycrystalline thin film, and high efficiency materials including gallium-arsenide-based alloys.

Question: How much efficiency do you need to reach for photovoltaic to become competitive with other energy generating options excluding tax incentives?

Answer: Competitiveness of electricity from utility-designed photovoltaic systems relative to other utility power-generating options is the DOE program goal. This competitiveness is a function of the total cost of electricity produced over the life of the plant, and requires improvements in both the efficiency and the cost of photovoltaic modules. Module efficiency objectives for competitiveness are in the range of 15 to 20% for flat-plate systems and greater than 25% for concentrator systems. The manufactured-cost objective for modules is to achieve better than $1 per peak watt.

Question: How much do you have to reduce the cost for solar thermal technology to be competitive?

Answer: To become competitive with other energy generating options without tax incentives, solar thermal cost must still be reduced by a factor of 1.5 to 2. A new generation of concentrators, receivers, and energy conversion devices for parabolic dish and central receiver technologies is being pursued. These improved components have the potential to significantly contribute to the reduction in cost of solar thermal electricity from the present

13¢/kwh to 5-7¢/kwh for electric power production and to $9/MBtu for thermal energy, the long-term program goals.

Question: How will you use the $14 million requested for solar thermal? Are any funds to be used to construct or demonstrate thermal systems?

Answer: Of the $14.088 million requested for solar thermal, $6.82 million will support Collection Technology Research, $2.935 million will support Energy Conversion Technology Research, and $3.405 million will support Systems and Applications Technology Research. Planning and Assessment activities will continue at $840 thousand and $88 thousand will provide for laboratory test equipment. Specifically, within the collection activity, $1.2 million will support research on silvered polymer and front surfaced silver steel optical materials, $2.62 million on stretched membrane heliostats and dish concentrators, and $3.0 million on design and testing of optimum central receivers and dish receivers. Within the energy conversion activity, $2.075 million will support research on free-piston Stirling and Thermo-electrochemical engines, $210 thousand on solar direct conversion basic research, and $650 thousand on thermochemical transport designs and field testing. Within the systems and applications activity, $200 thousand will support central receiver and distributed receiver advanced controls R&D, $1.6 million on design and evaluation of optimized central receiver subsystems and systems, and $1.605 million on design and evaluation of advanced dish subsystems and systems.

Solar Thermal research emphasis has been shifting away from large costly demonstration projects and is focussed on research on components and subsystems. This has resulted in improving performance and reliability while reducing concentrator, receiver, and storage costs by 50%. No fiscal year 1988 funds are planned to be used for the construction or demonstration of thermal systems.

Question: What are the priorities in photovoltaic research and how much money are you applying for demonstration or projects in FY 1988?

Answer: The first priority in photovoltaic research is to develop the materials technology that leads to considerable advancements in the efficiency, cost, and durability of photovoltaic cells. We depend on industry to reduce these technology advancements to practice, and deliver photovoltaic modules and systems that ultimately will be approximately one sixth the cost of present systems. This then accomplishes the goal of the program, which is to provide a technology base upon which industry can build to make electricity from photovoltaics competitive with utility-generated power from other resources. The President's budget request assumes no demonstrations or projects in FY 1988.

Question: Are there any commitments by your office to build or grant money to build a photovoltaic project or demonstration?

With such budget constraints as we have, it appears to me that demonstration projects would be among your lowest priorities; that such sums that Congress makes available for solar research would be more effective in basic research activities in new materials and better basic understanding of efficiency improvements. Do you agree?

We simply don't have the money to be demonstrating technology that is basically premature. These projects basically soak up new funds are available without significantly advancing the technology.

Answer: We agree that research on advanced materials and achieving better basic understanding of possible efficiency improvements is of the highest priority. There are no FY 1988 commitments to build or grant money to build a photovoltaic project or demonstration.

Question: How can $3 million requested for FY 1988 be used for OTEC systems. Why are we spending money in this area at all?

Answer: The FY 88 request for $3 million is designated to cover R&D in thermodynamics, experimentation, and materials/structures. In FY 87 the allocation for experimentation was about $1 million, with the balance going to the other two program elements. The FY 1988 request for experimentation will provide for validation of the analysis/hypothesis through the use of experiments and experimental hardware. In FY 88 the planned experimentation will require about $1.9 million. In FY 88 the thermodynamics element will reduce to about $1.1 million and materials to zero.

DOE is spending these funds to answer basic questions on performance and efficiency of Ocean Thermal Energy Systems. OTEC is one of the few renewable energy sources that provides baseload power. It could also be potentially attractive for island and coastal areas since desalinized water and mariculture are potential by-products. The answers to these basic questions, validated by seawater tests, are our basic thrust to bring ocean energy technology to a point where the commercial sector can make competent assessments to pursue and develop this technology.

Question: What would the $8 million for wind be used for?

Answer: The FY 1988 request provides for continuation of generic wind energy research, as outlined in the multiyear program plan. Of the $8.6 million requested, $1.1 million is proposed for atmospheric fluid dynamics research in turbulence, complex terrain effects on wind flow, and array performance studies; $4.0 million is requested in the aerodynamics research area to support continued cooperative research with industry, improvements in unsteady aerodynamic theory, and aerodynamic performance code improvements; for structural dynamics research, $1.8 million is requested to better correlate structural stresses with turbulence and resulting fatigue damage and to improve the present rudimentary methods for predicting fatigue lifetime; $1.6 million is requested for advanced components research including advanced airfoils and exploration of the benefits of variable speed wind turbine operation; the request for supporting research is $1.3 million for continuation of research on wind turbine acoustic noise generation and propogation, wind/diesel system integration studies, utility power quality studies, and program planning; and, $0.4 million is requested for capital equipment for improved data acquisition to enhance our ability to do research with industry.

Question: Do we have any mortgages on projects or demonstrations beyond 1988 on wind machines.

Answer: No, we do not.

Question: Does DOE have any wind machines that are currently operating?

Answer: Yes. There are several small turbines at the Wind Energy Research Center at Rocky Flats that are used for research and there is a 17 meter diameter vertical axis turbine used for airfoil testing at Sandia National Laboratory. Sandia will also be testing an advanced 34 meter Darrieus vertical axis experimental turbine located at a Department of Agriculture research site near Bushland, Texas. Testing of earlier DOE machines was completed in prior years and the majority of current testing is performed in cooperation with industry using commercial machines.

Question: What is the status of the Mod-5 wind turbine in Hawaii? How much money have we spent on the Mod-5 program? How much money is required for the Mod-5 wind turbine to be completed and become operational? How much money is needed for operations?

Answer: Installation of the Mod-5B foundation and tower has been completed. All major hardware is now at the site. Welding of the three rotor sections has been completed and final assembly is continuing.

The total government investment over the past 7 years in the Mod-5B development program is $57 million with an additional $5.7 million investment by industry. Also $12 million was spent for National Aeronautics and Space Administration research and development and management for both the Mod-5A and B.

We believe installation and initial operational checkout can be completed with current funding.

Question: Of the $71 million for solar energy how much goes to the Solar Energy Research Institute (SERI) directly or indirectly?

Answer: Based on the FY 1988 budget request of approximately $71 million for solar energy, $38 million is intended to support the research efforts at SERI. This figure includes some 32% subcontracting to industry and universities based on FY 1986 data.

Question: What are the institutional arrangements and requirements otherwise needed to increase the energy contribution of solar technologies to the point where 70% to 80% of space heating, hot water, cooling, and lighting requirements of many different types of buildings which I understand you assert could be supplied at costs that are competitive with conventional fuels? This is a laudable goal but I would like to know what it takes for us to get to that contribution of 70% to 80% point.

Answer: The building industry uses the same basic materials across a wide range of building types and climates. Historically, improvements in buildings have been based on improvements in these basic materials and the institutional arrangements are in place to allow such improvements to be realized in the building sector marketplace. The Solar Buildings Program research confirms that recent scientific advancements in optics and chemistry can be applied to building materials to create advanced materials to allow solar energy to supply a larger part of a building's energy needs. Performance measurements show that 35 to 40% of space heating, hot water, cooling, and lighting energy needs can typically be achieved with today's solar systems. To achieve the increased energy contributions of 70% to 80%, we are developing materials for "smart windows" that will transmit solar heat in the winter and reflect it in the summer. We are also developing phase change materials within drywall that can store and discharge thermal energy while retaining much better comfort conditions than the massive energy storage materials presently in use. These materials will simply replace currently used building materials with ones that appear identical, but in fact are different enough to allow for substantial solar energy contributions. To assure that these materials will ultimately be used by the building industry, we are working closely with materials manufacturers, and professional and trade associations in establishing the research agenda and reviewing scientific progress. This approach should address the institutional concern raised in your question.

Question: Please identify now or for the Record any projects or activities in your area that require appropriations after FY 1988. I have in mind the special demonstration projects or grants for demonstration projects that would have to be supported under a commitment made in prior years or in this year's budget. Please tell us the purpose of the project, its total cost and what contribution you expect it to make in advancing solar energy technologies.

Answer: The FY 1988 budget request does not include any demonstration projects that would require outyear funding. The majority of prior year demonstration projects have been successfully eliminated or completed. DOE is aware that project sponsors for the PVUSA project are likely to advocate further funding in FY 1988 or beyond. DOE is further aware that much of remaining industry members do not support PVUSA funding in light of higher priority research of potential benefit to a wider cross section of the industry. DOE is not fully knowledgeable on the current plans of PVUSA project sponsors and cannot currently estimate potential total project costs or the degree of cost sharing which might ultimately be offered.

Question: In the geothermal area, why has the geopressurized resource program been reduced? Why have you decided that heat from rocks should be the highest priority research? What are the technological barriers to a wider use of geothermal energy in the geopressurized resources area? What are the problems in the hot dry rock technology? How much money is required to determine if the private sector would be interested in contributing to overcoming these technical challenges?

Answer: The President's budget is adequate to achieve the goals set for the Geothermal Technology program. The hydrothermal activity is our highest priority effort. The hot dry rock (HDR), geopressured, and magma activities are also important components of the Geothermal Technology Program because of their large potential impact on energy contributions, although the pay-off is further in the future. The technological barriers to a wider use of geopressured geothermal energy are the uncertainty of the reservoir pressure maintenance mechanism and the associated ability to forecast the long term productive capacity of a reservoir. The technical barriers being addressed by the hot dry rock program focus on an understanding of the thermal draw-down characteristics of the reservoir and the ability to translate that to other sites. The HDR long term flow test will address these critical issues and will provide private industry with sufficient data to make prudent investment decisions regarding this technology.

GAO Concerns

Question: Ms. Walker, the General Accounting Office has recently written me expressing their deep concern over environmental safety and health aspects at DOE's numerous facilities. GAO has recommended to the Secretary of Energy, the development of an overall strategic plan addressing these issues and problems including a comprehensive picture of the environmental and safety and health issues facing DOE including the development of a ground water and soil protection plan. Actions are needed to insure that these facilities are operated in a safe manner and solutions to resolve these issues along with associated costs and timeframes. Are you familiar with the letter to Secretary Herrington? Has DOE formulated a response? Does DOE agree with GAO? How much of your budget addresses the issues raised by the GAO?

Answer: The Department is currently preparing a response to the recommendations contained in a March 12, 1987, letter from the General Accounting Office. We will of course provide a copy of that response to you.

In the interim, please be assured that the Department acknowledges the need for and has efforts underway to develop an overall strategic plan to address the full range of environmental, safety and health, as well as production issues related to its atomic energy defense activities. More specifically, with respect to environmental conditions at the Department's facilities, we have implemented a comprehensive environmental baseline information program. The purpose of the Environmental Survey is to identify, and establish priorities for correcting, existing environmental problems and areas of environmental risk DOE-wide. The Survey covers all major DOE operating facilities and all areas of environmental regulation. The results of the Survey program will be evaluated for purposes of identifying environmental compliance needs, assessing risk, establishing DOE-wide priorities, and developing long-range plans and cost estimates for correcting environmental problems and reducing environmental risks.

In addition, in connection with our responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), DOE has an ongoing process for the identification, characterization, and abatement of inactive waste sites. Under this multi-year process, DOE is completing the site identification phase at all major DOE facilities and is currently assessing the hazard potential of over 1000 inactive waste disposal or spill sites to determine which sites require further investigation under the detailed site characterization phase of the process. The results of the waste site characterization phase will provide the basis for planning and estimating the costs for necessary cleanup actions during the engineering assessment phase of the process.

The final phases of the process involve design and implementation of cleanup actions. For sites requiring prompt action, the phases can be conducted somewhat concurrently to accelerate implementation of cleanup work at several such sites. The current DOE process is essentially the same systematic process that EPA uses in its Superfund activities.

With respect to safety and health issues, the Department is conducting thorough Technical Safety Appraisals (TSA) of DOE's high and moderate hazard nuclear facilities by teams of experts led and directed by senior technical staff from the office of the Assistant Secretary for Environment, Safety and Health. In the course of these reviews, begun in February 1986, more than 50 nuclear facilities in 11 states will be examined. In addition to the detailed operational safety review, the TSA's will determine compliance with DOE requirements, implementation of applicable industry standards and guides, lessons learned, and good engineering practices. The results of the TSA program, along with those of Facility Design Reviews, will provide major input to current facility enhancement programs and long range strategic planning.

Funding Requirements

Question: What is the plan that DOE is operating under now? How much more money will be required in FY 1988 to develop a strategic plan along the lines recommended by GAO? Is your present budget adequate to respond to this high-priority initiative? What is the total estimated funding requirement over the next five years to deal with these issues? Do we have any idea at this point of the amounts required to fix these problems?

Answer: At this time, the Department does not have sufficient information for a reliable estimate of the total cost to correct the full range of environmental problems DOE-wide. However, our activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the DOE Environmental Survey and the Technical Safety Appraisal program, will provide the information necessary for such an estimate.

Policy in Handling Allegations

Question: What is your policy in handling allegations or issues brought to your attention that may have an imminent safety issue or concern?

Answer: The DOE Orders provide my office with the authority to curtail or suspend operations at any DOE facility whenever my staff determines that environmental, safety, or health conditions present a clear and present danger. Quite apart from this specific authority, I am fully prepared to recommend shutdown of any DOE facility which presents an unacceptable risk to workers or the public. This process is initiated by my notifying the Under Secretary, cognizant Program Secretarial Official, and Field Office Manager of the allegations or issues. Upon receipt of this notification, the cognizant Field Office Manager shall take immediate action to curtail or suspend operations to mitigate the danger.

Source of Technical Analysis Support

Question: Since you are the designated health and safety czar, do you rely upon a technical analysis from a team in your own office or from other areas within the DOE?

Answer: Environmental protection, safety, and health protection of workers and the general public is a the responsibility of every line manager. My office is an independent organization within the Department, reporting to the Secretary, which overviews the line programs to assure that the environmental, safety, and health policies of the Department are being implemented. In providing this assurance to the Secretary, my office utilizes the experienced staff within my organization as well as outside experts and technical people in DOE Field Offices, and DOE contractor organizations. In essence, my policy is to use the best talent available to address the issue while maintaining our independence from the line program organization. Therefore, depending upon the technical analysis needed, any one or combination of experts will be involved in either performing or reviewing technical analysis in support of resolving environmental, safety, or health issues.

QUESTIONS SUBMITTED BY SENATOR HATFIELD

Solar and Renewable Energy

Question: Last year in your testimony, you indicated that the contribution of renewable energy sources to overall energy supply was very important and growing. Please elaborate briefly on this trend.

Answer: Solar and Renewable energy are currently playing an important role in the Nation's energy supply mix - providing some 5.9 Quads (or 8.7%) of U.S. energy production. We are optimistic that renewable energy may represent as much as 8.7 Quads (11-12%) by the year 2000 and as much as 12.5 Quads (14-15%) by the year 2010 of domestic energy supply production. (Source: National Energy Policy Plan VI, 1987, unpublished). The actual rate of renewable energy growth in the future will, of course, depend upon the cost and availability of other energy supplies, the cost of capital, energy supplier and user decision criteria, and a number of other marketplace factors.

Question: Please give us an assessment of the role of the federal government in these contributions both the spending programs and the tax incentives.

Answer: In the area of spending programs, our primary, and proper role, is to fund the research necessary to evaluate the potential of the renewable energy resources and to establish a technology base for a range of viable technology-based energy supply alternatives which can utilize these resources to economically contribute to the nation's future energy supply mix. Our spending responsibility, as reflected in the FY 1988 budget request, focuses on areas of major scientific or technical uncertainty where advances of broad applicability can be obtained. In the area of tax incentives, we believe that efforts to simplify the tax system and to place maximum capability for decision making in the hands of the nation's consumers and business community are in the long term interests of renewable energy. In either instance, the federal role is one which should foster continuing development of a freer marketplace and should avoid substituting federal decisions for the natural forces of the marketplace.

Question: In light of the contribution of solar R&D, why is the budget request for solar activities, for example, reduced from about $124 million in FY 1987 to $71 million in FY 1988. What level was proposed by the Assistant Secretary during the executive branch/OMB review process?

Answer: The Department believes that the solar energy budget request reflects a commitment to sustain a balanced effort among the solar energy technology options in a manner which focusses expenditures on highest priority scientific and technical investigations. In order to accomplish reduced Federal outlays, the Department has had to examine and prioritize every funding proposal. No area within the Department escaped the review process. The proposed reductions in solar energy were largely taken in projects supporting specific engineering development activities more appropriately the role of the private sector. These activities are viewed by the

Department as lower priority and lower return to the industry as a whole than the basic and generic research being proposed for funding. As in every area of the Department, program offices made proposals which were subjected to careful scrutiny in light of the need to fund certain very high priority energy initiatives while meeting overall objectives for fiscal responsibility. During the internal review process the Assistant Secretary proposed $90.0 million for solar energy R&D.

Question: Congress provided $4 million last year for the Regional Biomass Program. What is the request for FY 1988? What is the reason for the reduction? Do you anticipate greater cost-sharing to provide the additional funding - from what source? Please provide a breakdown of how the reduction will be allocated in each of the regions with funding levels for FY 1987 and FY 1988.

Answer: For FY 1987, funding for the Regional Biomass Program of $4 million was equally divided among the Northern Tier, Southeast, Northwest, and Southwest regions. For FY 1988, no funds have been requested for this activity.

In the past, the Regional Biomass program has supported a wide range of activities, including resource assessments, case studies, technology transfer, and workshops. State energy offices, industry, universities, and federal agencies have been involved in the planning and selection of activities conducted within the regions. The Department believes this program has matured to the point where federal involvement is no longer crucial to sustain momentum. Activities which promote the use of biomass on a regional basis can be assumed by the individual states, local municipalities, and the private sector.

Question: How much is requested in FY 1988 as compared to FY 1987 for municipal waste activities? Provide an explanation of the proposed activities with a funding breakdown for each year.

Answer: The President's budget request for municipal waste research activities is $1.72 million. The FY 1988 request is consistent with the President's FY 1987 request of $2.3 million and reflects the administration's desire to exercise fiscal restraints.

FY 1988 municipal waste thermochemical conversion research will focus on data collection for kinetics and heat transfer models and environmental research on trace chlorinated emissions. These efforts will provide a data base for producing liquid and gaseous fuels from municipal waste. In addition, research will be initiated to develop an understanding of the relationship of municipal waste feedstocks to specific conversion processes. Biochemical conversion research will focus on optimizing reactor conditions, genetic manipulation of methanogens, and increasing methane production rates and yields. Progress in research has allowed DOE to focus on those technical issues which have been identified by DOE and industry as critical to the successful development of this technology.

Question: For the record, provide a detailed explanation and the funding levels in FY 1987 and FY 1988 for alcohol fuels activities.

Answer: The FY 1987 funding level for alcohol fuels research is $3.85 million. FY 1987 activities include research on plug flow and progressing batch acid hydrolysis concepts; enzymatic hydrolysis of woody feedstocks; and conversion technology for production of ethanol from hemicellulose and lignin, two major fractions of wood which are presently underutilized. The FY 1988 request of $2.18 million for alcohol fuels research provides for a balanced and focused research program capable of sustaining the momentum previously developed in the program and reflects the administration's commitment to exercising fiscal constraint. Activities will focus on the progressing batch reactor as the acid hydrolysis concept with the greatest potential; advanced enzymatic hydrolysis research, including development of advanced microbial enzymes; and further R&D on hemicellulose and lignin.

Question: Discuss briefly the progress and accomplishments of the photovoltaics industry over the last 5 years.

Answer: The progress of the U. S. photovoltaic industry has been impressive. Sales increased from 3.5 megawatts in 1981 to 8.7 megawatts in 1986. Production costs have been cut approximately in half, providing the basis for a similar reduction in the market price of the modules. Quality of modules has increased substantially to the point that ten-year warranties for maintenance-free operation are being offered. Large central utility projects and developments with photovoltaic rooftop systems have been installed privately with no DOE funding. These are working well. Last year, three companies introduced thinfilm power modules and thus became the first in the world to offer this advanced technology for power applications. The industry over the past five years has invested roughly $250 million of new capital toward research and plant construction. The U.S. industry continues to maintain world leadership in the development and sales of photovoltaic power modules, while Japan maintains market leadership in the less demanding area of photovoltaic consumer goods such as watches and calculators.

Question: Why do you propose a $9.3 million reduction in FY 1988 for PV systems research?

Answer: Systems research is proposed for phase-out because DOE believes that industry has a sufficient capability in this area to continue progress in an aspect of PV technology closer to industry commercial interests. With several prior successful DOE and private systems operating, higher priority is being placed by DOE on improving PV materials to improve efficiency.

Question: What is the impact of the $4.5 million reduction in PV collectors R & D?

Answer: The $4.5 million reduction in collector research reflects the priority of fundamental materials investigation over the, primarily, engineering nature of collector development. DOE believes that such engineering work is the responsibility of the industry in that it is geared to resolving questions unique to each firm's product, including testing and evaluation, to assess collector performance and reliability.

Question: There seems to be much less emphasis placed on technology transfer in the FY 1988 request and the line item is cut. Why?

Answer: The technology transfer line item provides for (1) publication of technical reports and research summaries for the solar energy research and development community and (2) operation of inquiry services for scientific as well as public inquiries, and (3) response to general requests for conservation and renewable energy information. The technology transfer activities funded within these areas reflect the overall level of DOE research activity and general levels of public inquiry and as a result, have been reduced consistent with reductions proposed for the technology research programs. Essential services and important research information will continue to be available to technical and general inquiries. The FY 1988 request of $2.09 million is roughly equivalent to the FY 1987 request of $2.0 million and reflects anticipated levels of R&D activities warranting publication as well as probable levels of general public inquiry. Much technology transfer occurs "unofficially" through the professional contacts of the researchers.

Question: In view of recent comments about the importance of international trade development of solar technologies why do you propose to reduce this program?

Answer: Funding from the International Program has been used to support two initiatives. The first is to support conferences, workshops, and reports to help make the U.S. renewable energy industry aware of the range of federal programs and services available to assist them in exporting. The second is to stimulate collaboration between individual renewable programs and other federal and international technical and financial assistance agencies in advancing these technologies towards eventual adoption as part of the agencies ongoing sector programs. The reduced FY 88 funding reflects the completion of the first initiative.

University Reactor Fuel Assistance

Question: What is the status of the program to convert university research reactors to low enriched uranium?

Answer: The twenty university reactors affected by the NRC rule have been contacted. Proposals for LEU fuel conversion have either been submitted to the Department or are in the process of being prepared. All the affected universities have been informed on when funds will be available according to our present schedule for funding the conversion process. The fuel fabrication contractor (Babcock & Wilcox) has developed a schedule for the fabrication of the LEU fuel for each reactor.

Question: As stated in House Report 99-1005, the Conference Report to accompany H. J. Res. 738, the Congress provided $2.9 million for LEU assistance to universities in FY 1987. How do you plan to allocate these funds in FY 1987. Please provide a breakdown similar to the one provided last year and also a breakdown which includes each university's allocation in every category.

Answer: The FY 1987 appropriation included $2.0 million for LEU fuel conversion and $1.9 million to support the regular reactor fuel fabrication and reactor sharing program. The additional $2.0 million for FY 1987 is being allocated as shown in the following table:

Argonne National Laboratory - Technical Support		$ 70,000
Reactor Safety Analysis Studies		
Worcester Polytechnic Institute	$ 25,000	
University of Missouri, Rolla	50,000	
University of Lowell	30,000	
Rhode Island Nuclear Science Center	9,000	
University of Virginia (CAV)	73,000	
Manhattan College	27,000	
Purdue University	67,000	
Iowa State University	100,000	
University of Florida	150,000	
University of Virginia (UVAR)	39,000	
Subtotal		570,000
Fuel Fabrication and Conversion		
Ohio State University	50,000	
Worcester Polytechnic Institute	310,000	
University of Missouri, Rolla	200,000	
University of Lowell	250,000	
Rhode Island Nuclear Center	300,000	
Manhattan College	250,000	
Subtotal		1,360,000
TOTAL		$2,000,000

Question: Describe the NRC mandated conversion rule and the procedure for DOE compliance.

Answer: The universities affected by the NRC rule are required to submit a plan to convert their reactors to LEU fuel. The rule also requires that Federal funding be available before the conversion process begins at each reactor. The Department of Energy is responsible for certifying that funds are available for LEU conversion and providing funds to support the necessary safety analysis reviews by each university. After NRC reviews the conversion plans submitted by the individual universities, then a directive is issued by NRC requiring the university to convert in accordance with the approved plan. At that point the Department of Energy is responsible for fabricating the LEU fuel and accomplishing the fuel interchange.

Question: Are there any insurmountable technical reasons for not converting these reactors to LEU?

Answer: We believe that there are no insurmountable technical reasons for not converting university reactors to LEU. However, the reactors at the Massachusetts Institute of Technology and at the University of Missouri, Columbia, are special cases. These reactors employ advanced thermalhydraulic designs and the highest uranium density in use with HEU fuels. Converting these reactors to LEU would require use of the most advanced fuels currently under development coupled with specific changes in the design of the fuel elements and reengineering of the core geometry of the two reactors.

Both MIT and the University of Missouri, Columbia, have applied to the NRC for a special case exemption from the LEU conversion regulation. It is important to note that in 1980 the Department initiated an extended life aluminide fuel program which is focused on increasing the amount of fuel in each fuel element thereby reducing by 50% the cost of supplying fuel to the MIT and Missouri reactors. This would also have the significant secondary benefit of reducing by half the amount of HEU fuel available for potential diversion thereby meeting the goals of the LEU conversion program.

Question: Please list all universities receiving any assistance in the past, indicate how much funding was received by each university, whether each has converted or agreed to convert to LEU and the date of conversion or anticipated conversion.

Answer: The following universities have received funding through FY 1986 for LEU fuel conversion including safety analysis studies and fuel fabrication costs:

University	Amount Received	Conversion Completed
Ohio State University	$ 410,000	FY 1987
Rensselaer Polytechnic	242,000	FY 1987
Worcester Polytechnic	40,000	FY 1987
University of Missouri, Rolla	77,000	FY 1988
University of Lowell	124,000	FY 1988
Rhode Island Nuclear Center	77,000	FY 1988
University of Virginia (CAV)	108,000	FY 1988

All these universities have agreed to convert their reactors to LEU fuel.

Question: Describe your plans for the HEU refueling of two reactors in FY 1988. How much is requested for each reactor? Why are these not proposed for conversion to LEU?

Answer: The two reactors that still require HEU fuel are the University of Missouri, Columbia and the Massachusetts Institute of Technology. The FY 1988 budget request includes $700,000 to provide HEU fuel for these two reactors. As noted earlier, an adequate LEU replacement fuel has not been developed which would allow these two reactors to be operated at their current power levels. Both reactors have applied to the NRC for an exemption from the LEU conversion regulation.

Question: List the 5 reactors which are proposed for stretch out of conversion in FY 1988. Indicate the funding level proposed for each and the amount needed to meet the earlier schedule.

Answer: Conversion of the following reactors will be stretched out beginning in FY 1988: Iowa State University; University of Washington; University of Florida; Purdue University; and the Georgia Institute of Technology. No funding will be provided in FY 1988 for the conversion of these reactors. Based on our present schedule the conversion of these reactors would be completed in FY 1991 at a cost of $500,000 per year from FY 1989 through FY 1991.

It is important to note that the critical path in the LEU conversion process involves the fuel fabrication contractor's capability of producing LEU fuel on a reasonable and orderly schedule. Additional funding beyond what is in our current budget estimate for FY 1988 and subsequent years would not speed up the fuel fabrication process.

Question: List the 7 reactors scheduled for conversion in FY 1987, the funding allocation for each and the date for completion of conversion.

Answer: Three reactors will have completed the LEU fuel conversion process at the end of FY 1987. These reactors and the total funding provided are as follows:

Ohio State University	$ 460,000
Rensselaer Polytechnic Institute	242,000
Worcester Polytechnic Institute	375,000

The following four reactors will receive funding in both FY 1987 and FY 1988 to complete the safety analysis review and fuel conversion process. These reactors will be completely converted by FY 1988:

University of Missouri, Rolla	$ 360,000
University of Lowell	340,000
Rhode Island Nuclear Center	369,000
University of Virginia (CAV)	373,000

Question: List the 20 reactor sharing awards with funding levels for each university. What is the purpose of these grants?

Answer: Funds are provided by the Department under the reactor sharing component of this program to offset the operating expenses of the reactors when they are used by researchers at other universities that do not have their own reactors. In FY 1986 twenty awards for reactor sharing support were made and are listed in the following table:

	FY 1986 Award
University of Florida	$ 22,000
Georgia Institute of Technology	30,000
University of Illinois	11,000
Kansas State	5,500
Massachusetts Institute of Technology	50,000
University of Maryland	12,000
University of Michigan	30,000
University of Missouri-Columbia	55,000
University of Missouri-Rolla	12,000
State University of New York	18,000
North Carolina State University	5,000
Ohio State University	20,000
Oregon State University	20,000
Pennsylvania State University	14,000
Reed College	9,500
Texas A & M University	35,000
University of Utah	10,000
University of Virginia	8,100
Washington State	20,000
University of Wisconsin	12,000
TOTAL	$ 399,100

We are in the process of making our selection of reactor sharing awards for FY 1987 and we will send this list to the Subcommittee as soon as it is available.

QUESTIONS SUBMITTED BY SENATOR McCLURE

Boron Neutron Capture Theory

Question: To what extent are the DOE and the National Cancer Institute development programs interrelated?

Answer: The DOE programs are directed to developing methods, testing for feasibility and testing for toxicity. Preclinical studies for determining biodistribution and toxicity are conducted by DOE. It is expected that more extensive clinical trials to evaluate efficacy of the method in humans will be conducted under the auspices of the National Cancer Institute (NCI). Also, the NCI currently supports a program in boron compound development that supplements the DOE effort in this area. Liaison with the NCI is maintained in part through attendance at meetings of the National Cancer Advisory Board.

Question: How do both programs fit into national plans for human clinical trials?

Answer: The national BNCT effort is coordinated through he Brookhaven National Laboratory. The Office of Health and Environmental Research of DOE has cognizance of all phases of BNCT research supported by DOE. Information about other programs is obtained largely by direct communication with the investigators.

QUESTIONS SUBMITTED BY SENATOR DECONCINI

Solar and Renewables

Question: I am greatly disturbed by the severe reductions the Administration has proposed for Solar Energy programs in FY 88. Admittedly, the funding for solar programs has continued to slip over the past six years. But, a 42 percent reduction, as you are proposing for Fiscal Year 1988, from $123.5 million in FY 87 to $71.1 million in FY 88, will essentially cripple any progress we had made over the years in the advancement of solar technologies. Did the Department propose the $71.1 million for FY 88 or was this an action taken by OMB? What will reductions of that size have on the future outlook for domestic development of solar technologies and their use?

Answer: As in every area of the Department, program offices made proposals which were subjected to careful scrutiny in light of the need to fund certain very high priority energy initiatives while meeting the overall Congressional and Administration objective of deficit reductions. The original Departmental request to OMB was $80.7 million for Solar R&D. Discussions reduced the request to $71.1 million in the Congressional submission. OMB advice was received in this area, as well as all other areas of the Department's request, which was considered by DOE in arriving at its formal submission to the Congress. The Department believes that its FY 1988 request reflects the results of this careful review and focusses on the proper priorities across its various areas of responsibility. The renewable energy request will meet the highest priority scientific and technical needs and will support momentum in realizing the economic potential of these promising technologies.

The President's FY 1988 budget request of $71.1 million for renewable energy represents essentially a level funding program compared with the FY 1987 request of $72.3 million. The types of research proposed for FY 1988 are essential to establishing the technical and economic viability of these technologies beginning in the 1990's when the nation's energy supply system will most need additional options. The program proposed for FY 1988 represents a committment on our part to realize the potential of renewable energy over the upcoming decade, while recognizing the proper Federal role and the need to reduce Federal budget deficits.

Question: I am particularly concerned about the 50 percent reduction proposed for photovoltaic research and development. This is one area in which there is general agreement the potential for sustainable energy sources could balloon. Where are we and where does the FY 88 reduction put us in terms of international competition for advancing solar photovoltaic technologies?

Answer: Progress to date in several photovoltaic materials R&D and system R&D areas has been rapid and steady. Program goals are being met generally on schedule in the principal materials and cell areas with several alternative photovoltaic materials potentially capable of achieving competitiveness of photovoltaic utility system power options. International competition in photovoltaic technology is clearly increasing both in R&D in all current materials areas and in manufacturing process R&D. The U.S. R&D efforts are considerably augmented by industrially-funded projects making the U.S. the world technology leader particularly in utility system power options, which are the primary focus of DOE and industry efforts.

Question: I notice that your budget justification indicates that all new ideas will be deferred for at least one year and that there will be no collector or systems research. At a funding level of $20.4 million, how many projects will be completed on schedule, how many will be stretched out, and how many will be completely abandoned?

Answer: The majority of the difference (70%) between the FY 1987 program as appropriated and the President's Request for FY 1988 is associated with engineering research or engineering development types of activities which were not supported in prior year requests and will be terminated or transitioned to private sector responsibility. The high priority materials research will be continued at levels ($20.4 million) consistent with the FY 1987 request ($19.6 million) maintaining a schedule for achieving economic viability in the 1990's for photovoltaics as a major energy supply technology.

Question: You are proposing to reduce the solar thermal program by $8.7 million from the FY87 level of $22.9 million. Over the years, I have expressed strong support for the cooperative work being undertaken by Arizona Public Service, Pacific Gas and Electric, Southern California Edison and the Department to undertake a pilot commercialization project on the solar central receiver technology. I know the Department has been very supportive of this work over the years.

Can you tell me what impact the proposed reductions for solar thermal activities will have on this project?

Answer: With prior year funding of the Utility Studies, Phase I, a conceptual design of a commercial plant, will be completed by both utility teams, Arizona Public Service and Pacific Gas and Electric. One utility team will then be selected for Phase II, to delineate the technology developments required to support private sector commercialization. The intent of the studies is to have the participating utilities complete an assessment of the technology and determine the design characteristics of a commercial plant. This will include evaluations and selections between molten salt and sodium as the preferred heat transfer fluid, advanced receiver and storage designs, and glass metal and stressed membrane heliostats. They will select, from a utility viewpoint, the best technology to incorporate in a commercial plant and recommend to DOE the developmental course necessary to ready the technology for transfer to the private sector. This effort is an important priority to the national program since it represents an important element in the transfer of the technology to the private sector and assists in selecting the proper research and development tasks. DOE will consider the results of these studies in assessing future technical content of central receiver research efforts which are currently focussed on critical issues attendant to the molten salt option.

Question: The FY 88 budget proposes a $528,000 reduction for solar buildings energy systems. I am interested in the continuation of work underway by Arizona State University and other institutions on the open-cycle solar cooling technology. Has funding been included in the budget for this research work and if so, what amount?

Answer: The Department's FY88 budget request includes $1.0 million for research in advanced cooling technologies with approximately $250,000 of that for open cycle absorption cooling research. This funding would include the Arizona State University program.

Question: Will this amount enable Arizona State University to maintain its contract with minimal reductions in staff, etc.?

Answer: The expected funding level for Arizona State University would be only slightly lower than that provided in FY 1987. On that basis, we would anticipate the impact on Arizona State University to be minimal.

Question: The funding cuts for R&D programs coupled with the loss of some tax credits leave the impression that our potential for long-term solar technology growth has been abandoned. What is the status of the solar industry in this country today and how do you perceive the role of this industry in future development of alternative energy sources?

Answer: Through continual interaction with industry, the Department refines its multiyear priorities for the various solar and renewable energy technologies. The FY 1988 budget request for solar and renewable energy reflects a Departmental consensus research agenda within the context of overall budget constraints. The funding levels for the FY 1987 and FY 1988 budget requests are about the same. However, the appropriated increase over the budget request for FY 1987 largely supported specific engineering development projects more appropriately the role of private sector. The Department views these types of activities as of lower technical priority and of lower return to the industry as a whole than the more basic and generic research proposed for funding. The Department believes that research of the type proposed for FY 1988 funding addresses the highest priority fundamental scientific and technical issues necessary for a technology base upon which industry can establish a broad range of renewable energy technologies as fully competitive energy supply options over the next several years.

Factors such as shifts in the price or supply of conventional energy supplies, the cost and availability of capital, shifts in basic requirements for energy, and evolution of contract offers under PURPA, present a challenging environment for the solar industry. While these factors exists, the Department notes that there are industrial interests in every technology, that we are able to secure industry participation in solar research, and that the current industry appears committed to sustaining that participation.

Question: In FY86, the Committee earmarked $425,000 for a demonstration project on the commercialization of the hot dry rock technology. While the language was not site specific, the area in which the demonstration was to be located was limited to the

Southern Rocky Mountain Region. In 1986, before the contract was awarded and after the FY 87 bill was marked-up, the Committee included language in its report stating that it preferred the Nutrioso site.

In light of the Committee's preference for a demonstration project at Nutrioso, why did the Department choose to award the contract using a different site?

Why was the Bechtel proposal chosen over the Navopache proposal?

Answer: In FY 1986, Congress directed the Department of Energy to proceed with a request for proposals for a hot dry rock project in the southern Rocky Mountain area. As a result of the competitive solicitation a contract was signed with Bechtel Corp.

Question: What is the status of that demonstration project? Can it be completed with the $425,000?

Answer: The contract is currently underway and will be completed in September 1987. The funds provided are adequate to successfully complete this activity.

Question: Is there any reason to believe that a second demonstration project would have value for commercialization of the hot dry rock geothermal technology?

Answer: In conjunction with the information developed at the Fenton Hill experiment along with the results of this study, private industry should have enough data to make prudent investment decisions regarding this technology.

Superconducting Super Collider

Question: I complement the Department for its leadership role in getting the SSC approved. As you know, there is tremendous support throughout the country for the continued search for the fundamental nature of matter and energy. You have proposed a supplemental request for $35 million in FY 88 for construction and research and development of the SSC. Do you have any suggestions as to where cuts should be made in the overall DOE high energy physics budget to accommodate this $35 million?

Answer: The Department submitted an FY 1988 budget amendment to the Congress which identifies in detail the allocation of resources within the FY 1988 request of $566.6 million to accommodate the $35 million for SSC activities. The amendment was necessary because the President's decision to approve the SSC for FY 1988 initiation occurred subsequent to submission of the original FY 1988 budget to the Congress.

Question: Does the DOE plan to curtail high energy physics projects further next year when the need for the SSC escalates to $348 million? If not, will other programs be affected?

Answer: No, we are proceeding on the assumption that the funding increment for the SSC in FY 1989 will be requested as an addition to the present program base level. It is clearly important to maintain a vigorous U.S. high energy physics program operating on the research frontier while initiating the construction of the SSC.

The Department is proceeding with SSC on the premise that funding for SSC will not come from other DOE basic research programs or from other agency science programs. Indeed, the Administration has proposed a strengthening of basic research in the U.S. by a doubling of the NSF budget over the next five years, as well as by the SSC.

Question: As you know, Arizona has expressed a strong interest in the SSC and plans to propose sites for consideration. Will more than one site be accepted from each state? If no, can you explain why not?

Answer: There is no limit to the number of sites a state can offer.

Question: Has the Department made a decision on whether or not a site proposed on Federal land will be considered?

Answer: Proposals to place the SSC partially or fully on Federal lands are acceptable.

Question: President Reagan recently approved the construction of the world's largest and most advanced particle accelerator, the Superconducting Super Collider (SSC). What developments in superconducting technology will be shared by both the SSC project, in the High Energy Physics Program, and the superconductivity R&D in the Electric Energy Systems program?

Answer: Developments in applied superconductivity that might be shared by the SSC project and the Electrical Energy Systems program will depend on the future interests of these two activities. The superconducting technology proposed for use in the SSC is based on niobium titanium, a material under development for use in magnets for some 20 years. This and other technologies have always been shared among various DOE programs with related needs and interests and will continue to be shared in the future. We anticipate, in particular, that further development in superconducting magnet technology and the control of power flow into and out of this type of magnet array, which has many similarities to inductive energy storage systems of potential application in electrical energy grids, will continue in the future to be of interest to the Electrical Energy Systems program, as it has in the past.

Question: Will the SSC project benefit from the discovery of new superconducting materials? In what ways?

Answer: SSC superconducting technology is based on the use of a niobium titanium superconducting alloy, which is employed in the fabrication of the flat cable that will form the magnet coils of the guide magnets which make-up most of the two large storage rings in the SSC. This material has required some 20 years of development to bring it to the present state of high performance and to be able to produce it in a cost effective manner in U.S. industry in the several million pound quantities needed for the SSC.

At present over 10,000 materials are known to exhibit the property of superconductivity. This list has been slowly and painstakingly accumulated since the Dutch physicist, Kamerlingh Onnes, first discovered the property of superconductivity in 1911. Until recently, all of the known superconductors shared the property of being superconducting only at very low temperatures (23 Kelvin on the absolute scale of -418 degrees on the more familiar fahrenheit scale). Such low temperatures are accessible only through refrigeration technology based on the thermal properties of helium. This technology is complicated and expensive.

Recently, new materials have been discovered which are superconducting at much higher temperatures (about 77 Kelvin or -321 degrees Fahrenheit). Seventy-seven Kelvin is the boiling point of liquid nitrogen, a major component (80 percent) of the atmosphere. Consequently, the new materials show promise for major new technical application using refrigeration systems based on the thermal properties of nitrogen. This refrigeration technology is well-established, relatively less complex, and more cost effective than the similar helium based technology.

The new materials are all complex oxides of a mix of four metals, one which is always copper. Consequently, they are all ceramic like, brittle in nature, and have limited electrical current carrying capacity. The new materials have immense promise for relatively near term application in instrumentation, communications, scientific research, and "cryogenic" computers. The brittle nature and low current carrying capacity of the materials investigated to date, however, make them unsuitable for use in large magnet applications. Therefore, at the present time, there is no reason to believe they will have a major impact on the magnet technology required for the SSC.

Question: Are there other potential mutual benefits in technology development? What coordination is taking place between the two programs?

Answer: Many areas of technology of interest to High Energy Physics and to Electrical Energy Systems are of potential mutual benefit. Examples include applied superconductivity, magnet technology, electrical power systems control, and cryogenic systems. Historically two areas of note, which have spun-off from High Energy Physics, are superconducting transmission lines and magnetic energy storage. The highly successful superconducting energy transmission line project completed at Brookhaven National Laboratory (BNL) was carried out by personnel drawn largely from the high energy physics group that designed and built the Alternating Gradient Synchrotron (AGS) facility at BNL. Superconducting magnetic energy storage employs very large solenoid magnets. The first large scale superconducting magnets of this type were originally designed and built for a series of bubble chamber detectors used in high energy physics research, including the 12 feet chamber at Argonne National Laboratory (ANL), the 15 feet at Fermilab and the 7 feet at BNL.

Coordination among DOE programs with mutual technology interests occurs at a variety of levels: formally, through committees convened for this purpose; and informally through frequent staff contact at the working level. Sometimes, projects of mutual interest will be jointly funded. Much of the R&D is carried out in DOE supported national laboratories wherein persons with special expertise will work on R&D projects of interest to several DOE programs. This is probably the most effective way of sharing and transferring mutually interesting technology among various DOE programs.

QUESTIONS SUBMITTED BY SENATOR INOUYE

Wind

Question: What is the program goal of the Mod-5B initiative?

Answer: The Mod-5 program was started in 1979 as last in a series of government sponsored large wind turbine development programs for utility applications. The latest in wind turbine technology has been incorporated into the machine design. The Mod-5B turbine now being assembled in Hawaii should accomplish the goal of demonstrating to industry and utilities that such machines can be successfully built and operated in modern power systems.

Question: What is the total Federal investment in the Mod-5B program date:

Answer: To date the government investment in the Mod-5B development work is $57.0 million.

Question: What amount of appropriated funding remains to complete the Mod-5B?

Answer: We believe the current FY 1987 funding of $4.5 million will be sufficient to complete installation of the machine and initial checkout.

Question: Does the Department of Energy have sufficient funds on hand to complete acceptance testing on the machine?

Answer: No. Available funds will complete initial checkout. Doe has requested no further funds for this project.

Question: What amount of additional funding do the project sponsors recommend to assure the completion of the project? By completion I mean adequate acceptance testing, final reporting and contingencies to cover possible problems during the testing period.

Answer: Hawaiian Electric has recommended an additional $2.2 million for completing acceptance testing including about $1.0 million to fix possible problems that could occur in the first tests of a new experiment. They did not include about $0.4 million which this effort would necessitate for NASA oversight and technical assistance. DOE believes further testing should be left to the manufacturer and utility company to meet their needs.

Question: Can you tell the subcommittee the proposed schedule for the first rotation of the machine, the completion of acceptance testing; and the final report?

Answer: The current schedule is for first rotation in July 1987, with machine checkout using existing funding continuing through September 1987. The final report should be published in March 1988.

Question: Under the contract with Hawaiian Electric Industries to purchase the machine, can you tell me what relationship--if any--

exists between acceptance testing of the machine and the price Hawaiian Electric will pay for the Mod-5B?

Answer: Under the current NASA/HEI agreement, the purchase price is determined by the measured output of power and availability experienced during the testing.

Question: If no acceptance testing, or inadequate acceptance testing, were to occur would this have an effect on Hawaiian Electric's purchase requirements?

Answer: Hawaiian Electric has the right to refuse purchase of the Mod-5B if the acceptance testing is not completed, but since this would not be in their best interest we believe a mutually acceptable alternative can be worked out.

Question: If acceptance testing on the Mod-5B cannot be completed due to lack of funds, will this have any adverse impact on the purchase agreement between the Federal Government and Hawaiian Electric Industries?

Answer: Data on machine performance will be obtained during checkout testing. A formula will be worked out to determine a fair price based on these tests.

Question: What are the benefits to your department, the federal government and the wind community in general from the data generated during the initial period of operation of the Mod-5B?

Answer: The Mod-5B is expected to provide data for the first time on the benefits of a large scale variable speed wind turbine. This and many other new design features of this machine should provide test data needed to further validate turbine design and performance models on the largest wind turbine (320 foot rotor diameter) ever built. These test results should be helpful to future intermediate and large machine developers, as well as utilities.

Question: What benefits to the government, the wind community and private industry accrue if the Mod-5B is placed into commercial service by Hawaiian Electric Industries?

Answer: Utilities are expected to eventually be the primary market for intermediate and large wind turbines. Operational experience from this prototype will provide the utility industry and future machine developers, with valuable data on performance, power quality, operation and maintenance, environmental and siting issues.

Biofuels

Question: The two energy shortfalls in the seventies resulted in rather severe transportation fuel crises. With respect to renewable energy, what percent of your research funds has gone into developing alternative transportation fuels?

Answer: Funding for research on alternative transportation fuels as a percentage of the total obligated Conservation and

Renewable Energy budget has ranged from 7-10% during the last five fiscal years. The Department's Conservation and Renewable Energy programs continue to be actively involved in research to provide alternatives to transportation fuels. These efforts include research on the production of petroleum and diesel substitutes, and hydrogen as alternative transportation fuels. Conservation and Renewable Energy also supports a program in alternative fuels utilization. This effort examines the use of methanol as an automotive fuel substitute.

Question: It is understandable that most of your non-electrical R&D has focused on ethanol. However, technology assessments conducted by your Department have convincingly demonstrated that a biomass-to- methanol process is far more economically attractive in the mid-to-long term than ethanol. What plans do you have to support research to develop methanol? Is there anything Congress can do to facilitate this transition?

Answer: Thermochemical gasification to produce medium-btu gas is a step in the production of methanol from biomass. Analyses have indicated that the gasification step is the critical technical barrier to developing methanol-from-biomass technology. The subsequent transition from medium-btu gas to methanol is a well understood and commercially demonstrated process. The Department's planned medium-Btu gasification scale-up project, which will be cost shared by the private sector, is expected to provide results directly applicable to methanol production. In FY 1987, $360,000 is targeted for biomass gasification research, with focus on high moisture feedstocks and environmental concerns. The FY 1988 request for biomass gasification research is $250,000, which is sufficient to maintain the continuing research progress being made in the area of biomass gasification.

Question: The least developed technology for methanol production is biomass gasification, and the U.S. D.O.E. solicitation for cooperative agreement proposal (SCAP), currently in proposal evaluation phase, is a good start. What plans, if any, do you have for follow up to this program, in regards to further work on methanol production and on technology transfer? What plans do you have to assist industry in making the transition from conventional fuels to methanol?

Answer: The DOE Solicitation for Cooperative Agreement Proposal addresses scale-up of biomass gasification technology, the precursor to methanol production from biomass. The successful construction, testing, and evaluation of a pilot-scale facility should reduce the technical and financial risks associated with biomass gasification to the point where the private sector will assume responsibility for further development and commercialization of the technology. Additional bench-scale research in biomass gasification will continue in FY 1987 and FY 1988 and focus on high moisture feedstocks and environmental concerns. Through this and similar efforts, the Department continues to transfer technology developments to the private sector.

By cost-sharing with industry the costs of construction and operation of the medium-Btu gasification scale-up facility, the Department will be assisting industry in the transition to methanol fuels. After testing at this facility, the necessary data will be available to determine whether this technology is ready for private sector development and eventual commercialization. The technology to convert medium Btu gas to methanol is already at the commercial stage. The decision to commercialize the technology to convert biomass to methanol is ultimately the responsibility of the private sector, reacting to conditions of the marketplace.

Question: Our sugar and related industries throughout the Caribbean, Gulf and Pacific will probably never again satisfactorily compete on the world sugar market. There is good reason to believe that multi-product energy/chemical plantations offer a sensible substitute economy to preserve jobs, optimally utilize land and make America more productive in international competition. What has the U.S. DOE done to support this possible big impact future? What additional plans do you have over the next five years?

Answer: The Department is aware of the world sugar outlook. Short rotation energy research in Hawaii on sugarcane land has been supported every year since 1978. Continuation of this research on eucalyptus as well as the development of "energy" cane is planned in FY 1987. Future research activities are dependent on the effectiveness of R&D results in achieving technical program goals.

Hydrogen

Question: The Department of Defense and NASA have a seven-year plan to spend $3 billion to develop a hydrogen-powered aircraft. Both Departments have indicated that the Department of Energy is responsible for assuring adequate hydrogen supplies into the 21st Century. Tell me specifically what the U.S. DOE has done to accommodate this important national need?

I would particularly be interested in summaries of interagency meetings on this subject and reports from projects supported by your department to form the basis for hydrogen production.

Answer: DOE is continuing a multi-year research and development program studying the generation, storage, and transmission of hydrogen. A large part of the funding, approximately $15.0 million of FY 1987 funds, is used to fund research in Basic Energy Science sponsored by the Office of Energy Research. This research involves a variety of photochemical hydrogen research efforts aimed at understanding the photosynthetics and biological processes which may lead to the utilization of solar energy. In addition, other basic research includes effects of hydrogen on the properties of materials, the structure and behavior of hydrides, and hydrogen embrittlement studies. In other areas of DOE, an additional $8.0 million is being used to fund research in nuclear fission and fusion, fossil, and military applications. The research to date indicates that the development of economic hydrogen systems would require a long-term effort. Within my immediate organization, an additional $1.4 million of FY 1987 funds from the Office of Renewable Energy is being used to fund research in the more applied area. This includes medium-and high-temperature electrolysis, advanced storage concepts, and use of biological processes to produce hydrogen. These areas of research are supported within the Energy and Water Development accounts for renewable energy. Each of these projects publish periodic reports which can be made available to you and your staff. The FY 1988 request includes approximately $1.0 million to continue the research within my jurisdiction. With respect to interagency meetings, DOE has held discussions or visited project offices at NASA, DARPA, Air Force, and the Navy.

Question: What programs and plans do you have to develop innovative renewable energy techniques for hydrogen production?

Which general method offers the greatest long-term promise for large-scale commercialization before the year 2020 (it is recognized, of course, that basic research needs to be in place now (or soon) for major private sector involvement into the 21st century.)

Do you have a five-year plan for such an expanded program?

If so, please send me preliminary budget implications. If not, explain why.

Answer: The Solar Energy Research Institute will be tasked to continue in-house and contracted investigations into production of hydrogen from renewable sources. Additional research to improve the efficiency and lower the cost of hydrogen storage and hydrogen production via water vapor electrolysis is supported through Brookhaven National Laboratory. In our view, it is premature to attempt to select the technology offering the greatest long-term promise for hydrogen production.

As requested in Committee Report 99-719, the Department has begun to work with NASA and other agencies, including DOD, to prepare a five year plan for hydrogen activities. Several meetings have been held, and a plan outline and schedule have been agreed to. However, sufficient details are not yet available to make comments regarding budget implications.

Question: One excellent beginning is the hydrogen from renewable energy technology status assessment developed by the Solar Energy Research Institute.

This report recommended research priorities for a national program on the subject.

How are you following-up on these proposed plans?

Answer: A key conclusion of that study was that hydrogen-rich compounds, such as methanol produced from biomass sources, merited special attention. Other renewable energy sources may offer potential approaches for unique hydrogen production, but more study to develop and define actual processes was considered necessary. For example, the study did not specifically address renewable energy based processes to produce methane which is being addressed elsewhere within the overall DOE research program. To follow up on these findings, a special effort is planned through the Solar Energy Research Institute that will involve substantial assistance from several subcontractors. Most of the renewable technologies will be examined in more detail to assess the contribution that might ultimately be made toward economical production of hydrogen. Biomass will receive particular attention.

Ocean

Question: Congress has, over the past few years, augmented the D.O.E. request for Ocean Thermal Energy Conversion. Can you please provide a detailed accounting on how these funds have been expended.

In particular, as we are nearly half-way through the fiscal years, and the recission request for OTEC will not be approved, exactly how will you utilize the $2 million set aside for continued work on The Pacific International Center for high technology research (PICHTR) U.S.D.O.E. project?

Answer: Earlier budget augmentations by the Congress have been used to support the projects or research areas specified in the appropriations language. Generally, these have been in the areas of materials and structures research, thermodynamic research and analysis, and component evaluation or model validation through experiments. The $2 million set aside for PICHTR research in FY 87 will be spent in two catagories. Approximately 70% will be spent on component and system experimentation as part of the 165kW open cycle OTEC project. The balance will be spent on fundamental OTEC research and application studies that also are expected to contribute to the development of the 165kW project.

Question: With respect to the PICHTR OTEC project, Congress provided funds on the basis of the potential for non-federal cost-sharing.

Can you summarize how this cost-sharing is developing?

Answer: The details of the specific FY 87 contract are presently being negotiated between the Solar Energy Research Institute and PICHTR. PICHTR is a privately chartered not-for-profit entity which we believe is currently receiving support from the State of Hawaii, Japan, the private sector and DOE. The specific tasks and amount in which PICHTR and DOE will cost-share are being determined.

Question: The integrated open cycle OTEC concept, as is beginning to become clear, can be significantly assisted over the next few years by development of co-products such as freshwater, air-conditioning and protein.

What can congress do to expand the U.S. Department of Energy mandate to allow and encourage R&D on non-energy products of OTEC and other energy technologies?

Answer: The DOE Ocean Energy Multi Year Program Plan now includes consideration of non-energy co-products. In consideration of the current state of development of OTEC systems, additional effort on OTEC by-products is not warranted at this time.

QUESTIONS SUBMITTED BY SENATOR SPECTER

Question: Secretary of Energy John S. Herrington released a report on energy and security containing a recommendation for further industrial energy efficiency. It is my understanding that projects under these programs, such as the Energy Analysis and Diagnostic Center of Philadelphia, Pennsylvania, provide direct assistance to manufacturers in implementing energy conservation measures. Yet the Department of Energy's 1988 budget request contains a 41 percent reduction in energy conservation research programs and termination of state and local assistance programs. What are the justifications for reducing the conservation programs in light of Secretary Herrington's report and what measures will the Department of Energy implement to achieve the objective of increased industrial efficiency if such reductions were made?

Answer: In keeping with current national efforts to reduce the budget deficit, the decision was made to focus efforts in the industrial conservation area on highest priority research and development work. In the case of the Energy Analysis and Diagnostic Center (EADC) Program, State or local governments could provide funding to continue programs of this type.

State and local assistance programs are not being terminated as a result of the Supreme Court's decision in the Exxon overcharge case, approximately $2.1 billion is being made available to the States for use in the grant programs, and the Low-Income Heating Assistance Program in the Department of Health and Human Services. In addition, as a result of the Stripper Well settlement the States received $750 million for use in energy-related activities. These disbursements constitute a very substantial increase over appropriated grant funded levels of the past few years. Therefore, no appropriated grant funds will be needed in FY 1988 for State and Local Assistance Programs.

Given the hard budget choices which have to be made, the emphasis on continued R&D is the only option which insures the availability of new technologies to help keep industry competitive in the future.

QUESTIONS SUBMITTED BY SENATOR SASSER

Magnetohydrodynamics

Question: The University of Tennessee Space Institute at Tullahoma, Tennessee, is one of the foremost energy research facilities in the United States. Currently it is a leader in the field of MHD, or Magnetohydrodynamics, which is a highly efficient, clean way to produce electricity from coal. This is a project of the utmost concern to the American people. The United States cannot afford to abandon the study of more efficient and cleaner energy sources.

I am deeply troubled that DOE has been cutting UTSI's budget more and more every year -- to the point that the Space Institute has recently had to layoff a significant number of employees. Will this improve in the future?

Answer: The Department of Energy embarked upon a proof-of-concept testing program in magnetohydrodynamics (MHD) in FY 1985. The plan for the proof-of-concept testing program was provided to the Congress in June 1984 and the Congress has continued to appropriate funds for the proof-of-concept program. The University of Tennessee Space Institute (UTSI) has been charged with the design, construction, and operation of an integrated, proof-of-concept bottoming cycle, which is one of the essential elements of the MHD program. Funding for the UTSI during the period FY 1984 - FY 1987 is listed below, together with the funds for the MHD program:

($ in thousands)

Fiscal Year	MHD Program	UTSI	Percent of Overall MHD Program Funding
1984	$29,867	$5,937	19.9%
1985	$30,721	$7,100	23.1%
1986	$27,717	$6,722	24.3%
1987	$26,500	$6,700	25.3%

As indicated, UTSI funding increased due to equipment purchases at the start of the POC program, then diminished but has remained relatively constant, with in fact a slight increase in funding as a percentage of overall program funding.

The Department has not requested funding for the MHD program in FY 1988 since MHD is viewed to have development costs which are not affordable in light of current fiscal constraints and other Fossil Energy priorities.

Superconducting Magnets

Question: Several years ago, DOE made the two largest superconducting magnets in the world. Both of them were made for the Tullahoma Space Institute. The first magnet was traded to Russia by this Administration. And now the second magnet has been in storage at Argonne National Lab for the past 4 years, because DOE won't provide funding to have it shipped to Tennessee. This is a real problem. How and when are we going to see that this magnet reaches Tennessee?

Answer: High field magnets are required in magnetohydrodynamics (MHD) power systems to generate electric power from MHD channels, which are the critical elements in MHD topping cycles. The Department of Energy contracted with the Argonne National Laboratory (ANL) for the design, construction and fabrication of two superconducting magnets.

The first magnet, the SCMS-1, was built specifically for use in connection with the US/USSR Program of Scientific and Technical Coordination in the late 1970s. That magnet is currently stored at the Institute of High Temperatures in the Soviet Union.

The much larger SCMS-2, the second magnet which is currently stored at ANL, was designed for use in the MHD program at a time when parallel topping cycle activities were planned for both the UTSI facility and another facility located in Montana. Subsequently, the program was redirected to a proof-of-concept program that provided for complementary, interrelated but separate topping and bottoming cycle efforts (as described in the MHD program plan submitted to the Congress in June 1984). The bottoming cycle development activities were assigned to the Tennessee facility. The topping cycle development effort was assigned to the Montana facility. The SCMS-2 which was configured for use at UTSI, but could also be used at other facilities, has remained at ANL pending a determination of its most cost effective use in the MHD program.

Acid Rain and the Greenhouse Effect Study

Question: The Department of Energy contracted with the Space Institute and Brookhaven National Labs recently for the study of a comprehensive approach to minimizing air pollution problems such as acid rain and the greenhouse effect. I want to encourage DOE to release the remaining funding for this project so it can be carried to completion. Do you see any problems with the release of the rest of the money for this study?

Answer: In December 1986, funds in the amount of $400,000 were provided to the Brookhaven National Laboratory by Fossil Energy. These funds were to provide program planning information and direction for environmental technologies applicable to Fossil Energy programs. As a result of changes in Fossil Energy program priorities, we are negotiating some changes in the direction of this project with the laboratory and its subcontractor, the University of Tennessee Space Institute. Rest assured that no funds will be withdrawn from this project and our recent change in scope will produce a more focused product that will enhance the environmental aspects of the Fossil Energy R&D program.

SUBCOMMITTEE RECESS

Senator JOHNSTON. With that, the committee will stand in recess until next Wednesday.

[Whereupon, at 3:40 p.m. Wednesday, March 18, the subcommittee was recessed to reconvene at 2 p.m. the same day in closed session.]

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

WEDNESDAY, MARCH 25, 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2 p.m. in room SD-116, Dirksen Senate Office Building, Hon. Bennett Johnston (chairman) presiding.

Present: Senators Johnston, Stennis, DeConcini, Hatfield, McClure, and Domenici.

DEPARTMENT OF ENERGY

NUCLEAR WEAPONS TESTING AND RELATED ACTIVITIES

STATEMENT OF ADM. SYLVESTER R. FOLEY, JR., ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

ACCOMPANIED BY:

- **HON. ROBERT BARKER, ASSISTANT TO THE SECRETARY OF DEFENSE FOR ATOMIC ENERGY**
- **DONALD OFTE, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY**
- **JAMES W. CULPEPPER, ACTING DEPUTY ASSISTANT SECRETARY FOR MILITARY APPLICATIONS, DEPARTMENT OF ENERGY**
- **RICHARD D. HAHN, ACTING DIRECTOR OF WEAPONS RESEARCH, DEVELOPMENT, AND TESTING, DEPARTMENT OF ENERGY**
- **IRVIN WILLIAMS, WEAPONS RESEARCH, DEVELOPMENT, AND TESTING, DEPARTMENT OF ENERGY**

Senator JOHNSTON. Gentlemen, welcome to the committee.

This will be a very interesting and very vital session this afternoon, as far as I am concerned. Today, we will be dealing with the nuclear weapons testing program of the Department of Energy.

As you know, it is a vital issue of the day in the Senate, with various testing moratoria that are being proposed and considered. So, I hope we can establish a record here today which will get to the bottom of the need both for testing and the impact that a moratorium would have on this important activity.

First, Admiral Foley, Assistant Secretary of the Department of Energy, will speak on this, and then we will take our other witnesses seriatim, and then have some questions.

Admiral Foley.

Admiral FOLEY. Thank you very much, Mr. Chairman.

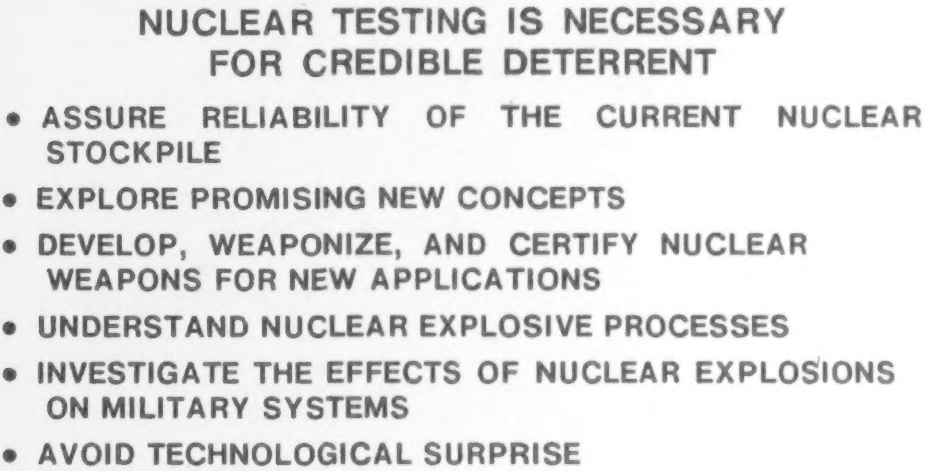
I have a statement that I would like to submit for the record and a few viewgraphs that I will talk to as we go along to try to set the scene. Then I will be followed by Dr. Batzel and Dr. Birely.

Please interrupt at any time as we go along because the value, as I see it today, is the dialog back and forth, so that we have a full exposition and understanding of what we are talking about.

[A series of slides was shown.]

NEED FOR WEAPONS TESTING

Admiral FOLEY. You have seen much of this before, Mr. Chairman, in terms of the necessity for testing—reliability, exploring new concepts, and certifying new nuclear weapons. Safety is an issue for us, and the need for an understanding of how the process works. I think I would have to stress that issue to a greater degree than I have seen in the past.



NUCLEAR TESTING IS NECESSARY FOR CREDIBLE DETERRENT

- ASSURE RELIABILITY OF THE CURRENT NUCLEAR STOCKPILE
- EXPLORE PROMISING NEW CONCEPTS
- DEVELOP, WEAPONIZE, AND CERTIFY NUCLEAR WEAPONS FOR NEW APPLICATIONS
- UNDERSTAND NUCLEAR EXPLOSIVE PROCESSES
- INVESTIGATE THE EFFECTS OF NUCLEAR EXPLOSIONS ON MILITARY SYSTEMS
- AVOID TECHNOLOGICAL SURPRISE

We talk about simulation. We talk about lots of other processes. But I must tell you that the explosion itself, this very test, resolves most of the uncertainties and comes up with new situations for us and things that we did not understand.

It is a very complicated process, and we just do not know all the answers.

STOCKPILE RELIABILITY

Senator JOHNSTON. Well, first, let me start with reliability. Is that reliability not related to age?

Admiral FOLEY. Some of it is.

For example, we have weapons in the stockpile where we put in a modification which extends their life equally as much as we had in the first place. In other words, for a 15-year-old weapon, we can extend it out to 30 years. So as a function of chemical deterioration, reaction of the materials inside, we see——

Senator JOHNSTON. I mean that it is a function of age, as opposed to this. Once a weapon is initially tested and deployed, after it has been in the stockpile 1 year, you won't take it out after a year and check it for reliability, will you?

Admiral FOLEY. Yes; we do. After they are in the stockpile, we take them out.

I must tell you that one-third of the current generation of weapon designs that we have in the stockpile we have found things wrong after we have done the development and put them into production.

Senator JOHNSTON. But you don't test them by exploding them?

Admiral FOLEY. Yes, sir; we do.

Senator JOHNSTON. Well, obviously, after you take one out and explode it, then it does not matter whether it was good or not.

Admiral FOLEY. Sure it does. After you take it out and explode it, you find out that it does work and that it does what it is supposed to do to its design features. Suppose you push the button and it does not go up at all. We have had that happen.

Suppose you expect a 150 kt yield and you get 25?

Suppose you expect a 25 kt yield and you get 40, or something along those lines.

Senator JOHNSTON. You don't have those tested initially?

Admiral FOLEY. Oh, yes, sir. But it doesn't always come out as predicted. I will let the experts who have walked through this and who have considerably more history than I, give you examples as we go along.

Senator JOHNSTON. What percentage of your weapons stockpile do you test after 1 year?

Mr. CULPEPPER. Sir, I am James Culpepper. We have conducted [deleted] stockpile confidence tests since 1979. Most of these were full-up systems, pulled out of the stockpile and tested. This is an effort that we have had between the Department of Energy and the Department of Defense to assure that the full-up systems we have introduced are doing what they should and are operating the way we think they should.

Senator JOHNSTON. Of those [deleted] tests, how many were 1 year or less?

Mr. CULPEPPER. [Deleted.]

Senator JOHNSTON. [Deleted.]

Mr. CULPEPPER. [Deleted.]

Senator JOHNSTON. [Deleted.]

I am talking about systems like your Minuteman, for example, If your deployed Minuteman is out there for a year—were any of these [deleted] tests done for that sort of thing?

Mr. CULPEPPER. Yes, sir.

Senator JOHNSTON. How many?

Mr. CULPEPPER. [Deleted.]

Senator JOHNSTON. [Deleted.]

Mr. CULPEPPER. Most of them were less than 1 year.

Senator JOHNSTON. Right. [Deleted.]

Dr. BATZEL. [Deleted.]

Senator JOHNSTON. [Deleted.] As I understand it, there are two things you want to read.

I read your book last night. It says that you do two things, principally. You have expanded it out there on the chart a little bit, but, principally, it is reliability, which really is a function of age, and new weapons which you test essentially before you deploy.

I am sure this has to be right. Reliability, basically, is a function of age. I would be willing to bet that of those [deleted] tests, none of them were fully deployed weapons in the first year, because you tested them before you deployed them. Why put them out there only to take them right back in after a couple of months?

Dr. BARKER. Senator Johnston, may I join this panel?

I am Dr. Robert Barker, Assistant to the Secretary of Defense for Atomic Energy.

STOCKPILE CONFIDENCE TEST

I think, in part as a result of Defense Department prodding some years back, there is such a thing as a stockple confidence test done routinely these days, and within the first year—in fact, usually within the first 6 months—after a system is deployed. This was not routine up until about the mid-1970's sometime.

Dr. BATZEL. It was the late 1970's.

Dr. BARKER. So, as a result of work between the Defense Department and the Department of Energy, the Department of Energy agreed to conduct one test of an early production item between the time of deployment and some 6 to 12 months later, in which that warhead was actually put into the stockpile and subjected to some of the environments that such a weapon is subjected to—the rail transport and the truck transport. So, the jargon gets mixed up. But, generally, I think we agree that those are called stockpile confidence tests, tests in which we establish the confidence that what we have built on the production line will really do what the R&D program has designed it to accomplish.

In addition to that, there are——

Senator JOHNSTON. Well, just like I said, I think you ought to test these things during the first year.

Admiral FOLEY. Sir, we do.

Senator JOHNSTON. I am kidding, of course.

Dr. BARKER. Over and above that there is the reliability test, where they may discover something in the stockpile that causes them concern. This may then prompt a nuclear test.

There are two categories of tests I think in that first line that Admiral Foley has up on the chart.

Senator JOHNSTON. OK; that questions has been answered, so far as I am concerned.

Please go ahead, Admiral.

ADVANCED WEAPONS R&D

Admiral FOLEY. This shows new concepts. That is self-evident, in itself. To develop, weaponize, and certify nuclear weapons for new applications—that is the same sort of thing. I would lump lines 2 and 3 together. Nuclear explosive processes are where we seek a better understanding of the complexity of the explosion itself, the fundamental physics.

The effects of nuclear explosions on military systems—we need to do this for the Defense Nuclear Agency [DNA], for example. How do our nonnuclear systems react to that kind of environment? What is the effect on them?

We do these tests, usually two a year, for the Defense Nuclear Agency and also to avoid technological surprise.

You can use the most far-fetched example. If you were a nonnuclear country and suddenly somebody sets off a nuclear weapon——

Senator JOHNSTON. I understand that.

[Chart deleted.]

NUCLEAR TESTING TRENDS

Admiral FOLEY. This shows trends. This will give you a feel for how we have done since 1981 on up to now—the technology base, the number of DOE tests that we have had, where the number has gone consistently down since 1983. We have, I believe, [deleted] that are slated in the budget this year. We will pick up a couple from DNA and usually one from the British also. So, it is a total of [deleted] Senator.

We are planning between [deleted] nuclear directed energy SDI-type tests in each of the next 2 years.

There is a statement that, even with a moratorium in the last 10 years, the Soviet Union has conducted more nuclear tests than we have.

If you want to go back to the very beginning of the nuclear test program, quite obviously we have set off more tests than they have since the time of World War II, but they are [deleted] over us in megatonnage, in terms of the dimensions of the tests that have gone off.

But I think that there is an impression that we always set off more tests than the Soviets, and that is not correct at all.

Senator DECONCINI. Do you have the number? Do you know how many the Soviets have done in the last 10 years?

Admiral FOLEY. The answer is yes, sir.

Senator DECONCINI. Versus how many that we have done? Is that up there?

Mr. CULPEPPER. Sir, since 1976, I think the Soviets have conducted [deleted] tests, since we have been operating under the Threshold Test Ban Treaty, [deleted] including the most recent two tests, and I think we have conducted about [deleted] in that same period of time.

Senator DECONCINI. Is that number classified?

Mr. CULPEPPER. Yes, sir.

Those are only the tests that we have been able to identify. There may be other tests that they have conducted that we have not been able to identify.

Senator DECONCINI. Thank you.

Thank you, Mr. Chairman.

Admiral FOLEY. I will briefly discuss these next slides. The lab representatives will cover them in more detail.

[Chart deleted.]

CURRENT WEAPONS IN THE STOCKPILE

Admiral FOLEY. These are current weapons.

This [indicating] is the current stockpile. these are not ancient history. These are present weapons in the stockpile and things that we have found wrong with them which had to be corrected or had to be tested afterward, after we put a fix on them, so we know whether or not they were corrected.

[Deleted.]

Senator JOHNSTON. [Deleted.]

Admiral FOLEY. Yes, sir.

Senator JOHNSTON. In the Poseidon, you actually had to do the nuclear test? That was not just a high explosive?

Dr. BATZEL. I am going to talk specifically about that. In fact, we did need to have a test.

Dr. BIRELY. [Deleted.]

INTENSIVE HIGH EXPLOSIVES

Admiral FOLEY. But one of the things that we know about insensitive high explosives, which we developed from the testing and that we can utilize, is that the two aircraft accidents that we had in Palomares and up in Thule, which spread radioactive material around when high explosives went off, that will not happen now.

You can shoot a bullet right through this insensitive high explosive and it will not go off.

Senator JOHNSTON. Is that HMX?

Dr. BATZEL. No; it is TATB, triaminotrinitrobenzene, for lack of a better chemical definition. [Laughter.]

[Chart deleted.]

SOVIET TEST LOCATIONS

Admiral FOLEY. Here are Soviet test locations.

We always talk about our Nevada Test Site. That is where we conduct all of our testing.

[Deleted.]

What is the composition of these peaceful nuclear tests? Can you take a weapon right out of the stockpile and use it for a peaceful nuclear test?

The answer is yes; absolutely.

So, when you want to characterize their tests as "peaceful nuclear tests," are they stockpile confident? It is certainly possible.

CORRTEX VARIATION TECHNOLOGY

I know that if I were doing it, I would do that.

Here is CORRTEX—just to give you a feel for it and not describe it in any detail. If you have any questions on it, we can respond to those.

It is intrusive to the degree that you dig a parallel hole down alongside and do your measurement right there. But you do not get down into the explosive emplacement hole itself, when there is not a need to go down and do that.

Senator DECONCINI. Did you say there is not a need?

Admiral FOLEY. No; there is not, sir.

You could, but the likelihood of someone letting you go down with the kind of intrusiveness is slim.

Senator JOHNSTON. You are confident of CORRTEX, then?

Admiral FOLEY. Confident within a [deleted] range. Yes, sir, we have no reason not to feel that way at this time.

Senator DECONCINI. Excuse me, Mr. Chairman.

What do you mean [deleted]. Is that a [deleted] error?

Admiral FOLEY. Yes, sir. [Deleted.] So, we never went down with the CORRTEX mesurement. We say that is the best. We may very well develop, in the future, something which brings it even closer. Or, if you could get into the geology of the country, go right in there and do a lot of measurements and establish a baseline, you could probably get down [deleted]. We don't know just how close you could get.

Senator JOHNSTON. When you say "seismic," how close must your seismic instruments be to get 2 to 1?

Dr. BATZEL. [Deleted.]

Senator JOHNSTON. You don't have to be in the Soviet Union to do that?

Dr. BATZEL. No.

Admiral FOLEY. No, sir.

Senator JOHNSTON. [Deleted.]

Admiral FOLEY. Perhaps. We would have to do a lot of measurements. [Deleted.]

Senator DECONCINI. Mr. Chairman, may I ask another question?

Senator JOHNSTON. Yes.

Senator DECONCINI. Are you working on anything more advanced than CORRTEX?

Dr. BATZEL. Not realistically. We know how to do it better than CORRTEX, but we are sure the Soviets will not let us do it that way.

Senator DECONCINI. Is that right?

Dr. BATZEL. Yes.

ADVANCED VERIFICATION METHODS

Dr. BIRELY. There are some exploratory nonseismic methods that have had fundamental scientific development, but they are not really deployed yet. So, in the near term, they are not realistic possibilities. They are something which, if we invested more resources in them, have a promise of being more accurate than the seismic method. But they just do not have the data base at this point.

Senator DECONCINI. Then what are we talking about? Do you have any idea?

Dr. BIRELY. Excuse me, sir?

Senator DECONCINI. What are we talking about? Is it more investment and time? If you had what you wanted to do this, what would you be talking about?

Dr. BIRELY. We are talking about methods that would take a matter of years to develop and investments on the order of tens to hundreds of millions of dollars.

Admiral FOLEY. But I think there is possibly a misperception that perhaps we ought to address for a second right now. That has to do with the seismic measurements and seismic testing.

If someone said: All right, we are going to have improved verification methods and we are going to put seismic stations around the Soviet Union. We are going to start measuring these things right now and then we will have improved verification. Well, we can't do that. We do not have those seismic measuring stations to put in the Soviet Union right now.

We are talking about $100 million-plus and anywhere from 18 months to 3 years to get these things built, state of the art, and put over there, in place.

Senator JOHNSTON. That is in the Soviet Union?

Admiral FOLEY. Yes, sir.

Senator JOHNSTON. But you can get within [deleted] by seismic not placed in the Soviet Union?

Admiral FOLEY. Yes, sir—for a high yield.

Senator JOHNSTON. How low does that go for seismic?

Dr. BATZEL. You can see or detect the events down [deleted]. But the accuracy degrades as you go from high yield to low yield. But it is difficult to say how much.

Dr. BIRELY. As you go to lower yields, natural events, chemical explosions, earthquakes, give comparable signals. So one has to discern between natural events and a nuclear explosion, as well as try to measure the yield of the explosion.

PREPARED STATEMENT

Senator JOHNSTON. I see.

Admiral FOLEY. That brief introduction, sir, is just to walk us on to the point where the laboratories will go into a more technical analysis. Dr. Batzel will follow with his presentation.

[The statement follows:]

STATEMENT OF ADM. S.R. FOLEY, JR.

Mr. Chairman and Members of the Committee. I am pleased to appear before you today on a subject about which I feel very strongly, not only as a government program manager but as a U.S. citizen and taxpayer. The subject is nuclear testing, its relationship to the weapons research and development program, and the Nation's nuclear deterrent. The credibility of our capability to deter war and avoid serious confrontation with the Soviet Union is the crux of the issue. I welcome the opportunity for us to exchange views on this subject, in a candid and constructive manner. Dr. Batzel, Director of the Lawrence Livermore National Laboratory, and Dr. Birely, Deputy Director for Defense, Los Alamos National Laboratory, will also provide statements. We will try to answer all your questions in the time you have provided following our short statements.

Nuclear weapon testing, contrary to the understanding of many, is not a separate program. Testing is an integral part of our nuclear weapons research and development, and our quality assurance activities for stockpiled weapons. Nuclear testing has always been and will continue to be an indispensable part of the design process because of the great complexities of nuclear weapon behavior. The processes cannot be completely modeled by computer nor adequately explored by nonnuclear laboratory experiments. As long as the United States has a requirement for nuclear deterrence, we will need nuclear tests to respond to the evolving threat with new military requirements and to maintain the credibility of the weapons in the hands of our military forces.

I recognize the intensity of national and international public debate on this subject. Unfortunately, the negative aspects of this debate seem to overshadow the original purpose of the Nation's nuclear deterrent. I also understand that the issue is very emotional. One of our basic concerns is to insure that the American public readily understands the function and the benefits that our nuclear weapons arsenal provides them. I would like to mention a few:

- First of all, it has provided a proven deterrent to full-scale war during the past 40 years.

- Second, it has allowed us to maintain much smaller standing military forces than would be required if we relied solely on conventional arms. As a result, our deterrent allows us to have a substantially smaller national defense budget.

- Third, our nuclear deterrent is provided at a relatively small overall cost. The Department of Energy Defense Programs budget is less than 3 percent of the Nation's total defense budget. The overall cost for our nuclear forces represents only about 15 percent of the total national defense budget.

I would like to briefly explain how testing is an integral part of a viable nuclear deterrent. There are four basic reasons for testing. First, we test to assure the proper functioning of our currently stockpiled weapons. Second, we test to modernize our weapons for enhanced safety, security, and effectiveness. Third, we test to measure the effects of nuclear weapons on our own weapon systems and on critical command, control, and communications in order to ensure their survivability if attacked by Soviet nuclear weapons. Finally, we test to enhance our understanding of nuclear weapons and to avoid technological surprise in order to assure our capability to respond to a changing Soviet threat. I'll briefly discuss each of these reasons for testing. (A fairly complete and unclassified summary of the role of United States nuclear testing is contained in our Policy Paper No. 5, which I'll leave with you.)

Maintain the Stockpile

Nuclear weapons are fabricated from radioactive and chemically active materials. Much as a piece of plastic deforms when left in the sunlight, nuclear weapons' components age and change in subtle, and often unpredictable, ways. Hard experience has shown that testing is required both to find problems and to assess the adequacy of solutions. Approximately, one-third of all modern weapon systems placed in the U.S. stockpile since 1958 have required and received post-deployment nuclear tests to detect and resolve critical stockpile problems. In three-fourths of these cases, problems were discovered by nuclear testing and nuclear tests were conducted to confirm fixes. Because of our inability to fully understand the effects of small changes on weapon performance, nuclear testing has been required to maintain the proper functioning of our Nation's deterrent. All nuclear tests contribute to the scientific data base used to assess and understand stockpile problems. In this respect every test adds to our confidence and enhances the credibility of our nuclear deterrent. We also perform dedicated tests with the specific purpose of verifying the performance of stockpile units.

Stockpile Modernization

The directions and emphasis of the U.S. modernization program have often been poorly understood. Contrary to popular belief, the so-called "arms race" has led to reductions, since the 1960's, in the numbers of U.S. nuclear weapons by nearly 25 percent and, in the total destructive yield, to one-fourth that of 1960 while simultaneously maintaining our national security. These reductions would not have been possible without nuclear testing. Of more importance, however, the primary focus of U.S. modernization is on the enhanced safety, security, effectiveness, and survivability of our nuclear deterrent forces. Few would argue that our nuclear weapons should not be safe and secure. Yet a ban on nuclear testing could preclude needed changes to the stockpile in these important areas. The global strategic balance is a dynamic, not a static situation. Developments in nonnuclear areas such as intercontinental ballistic missile accuracy, antisubmarine warfare, and air defense strongly influence the need for new, more survivable weapon systems.

Nuclear Effects Testing

A very important part of the nuclear testing program is testing the effects of nuclear weapons on a vast array of military equipment. Of particular importance are the nonnuclear components of our strategic weapon systems, warning sensors, and communications equipment which must work in a nuclear environment. If deterrence is to work, our forces must not present vulnerable targets to the Soviets, encouraging them to take advantage of us in a crisis.

Technological Surprise

We test to obtain scientific knowledge to enhance our fundamental understanding of nuclear weapons, explore new concepts, and avoid technological surprises.

Under restrictive nuclear test limitations, U.S. options for responding to an evolving Soviet threat would be severely constrained. As in the past, our ability to react to new Soviet developments may involve changes in our nuclear forces. We may need new delivery systems which will require new warheads, and nuclear testing is essential to their development. A key factor in avoiding technological surprise is the maintenance of skilled scientists with the necessary scientific judgment to evaluate potential technological developments by our adversaries that could threaten the viability of our nuclear deterrent. Based on our experience from the 1958-1961 moratorium, we must be ready and able to promptly respond to surprises. Should the Soviets break out of a test limitation treaty, or try to evade it, we must have the experienced personnel with the necessary skills to respond. I believe it is easy to see that without testing, we would see an erosion of our deterrent in terms of credibility, reliability, survivability, and a sound technology base.

Current Test Limitations

The U.S. nuclear test program is currently conducted under several limitations. The Limited Test Ban Treaty (LTBT) bans explosions in the atmosphere, under water, and in outer space. The Threshold Test Ban Treaty (TTBT) limits the yield of each underground nuclear explosion to less than 150 kt. In spite of these limitations, we have been able to carry out our mission. However, there are constraints: certain stockpile maintenance tests are precluded and we have to use pre-TTBT tested warheads for new, higher yield weapon systems. We want to be confident that the Soviets are equally constrained. That is why I strongly support the President's proposal to ratify the Peaceful Nuclear Explosion Treaty and the TTBT with improved verification. The President has pledged to ratify these treaties and to proceed with a parallel program to reduce and ultimately eliminate both nuclear weapons and nuclear testing. I wish to emphasize that additional test limitations alone will not achieve these goals. Limitations on testing will not subtract a single weapon from either side's arsenal. What is needed is mutual, verifiable arms reduction. Ratification of these treaties, with improved verification, would be a significant confidence building step toward this goal. The Department of Energy supports these efforts and encourages the Senate to assure that no further testing limitations are mandated prior to having appropriate arms reductions in place.

Soviet Testing

I would like to say a few words about the resumption of Soviet testing. As you know, they resumed testing at Degelen Mountain on February 25, 1987. (First test since July 25, 1985.) Two hours after the detonation they announced the event was a physics test with a yield less than 20 kilotons (kt).

Deleted

The second Soviet test occurred on March 11, 1987, at Shagan River. The Soviets also announced that it had a yield up to 20 kt, and that it was conducted for the purpose of improving military equipment. *Deleted*

In conclusion, we consider testing to be a vital and integral part of the weapons research, development, and stockpile assurance programs that provide the Nation with safe, secure, survivable, and reliable weapons. Without nuclear testing, we can only expect an erosion in the credibility and survivability of the Nation's nuclear deterrent.

In closing, I would like to quote Sir Winston Churchill: "Be careful above all things not to let go of the atomic weapon until you are sure, and more than sure, that other means of preserving peace are in your hands."

Thank you very much.

STATEMENT OF ROGER E. BATZEL, DIRECTOR, LAWRENCE LIVERMORE NATIONAL LABORATORY

ACCOMPANIED BY GEORGE H. MILLER, ASSOCIATE DIRECTOR FOR DEFENSE SYSTEMS, LAWRENCE LIVERMORE NATIONAL LABORATORY

Senator JOHNSTON. Thank you very much, Admiral.

Dr. Batzel, you are from the Livermore Lab.

Dr. BATZEL. Thank you, sir. Let me say that I am really speaking for both Los Alamos and Livermore when I discuss these issues.

What I want to do is go through our nuclear weapons technology and make sure you understand what we are talking about in terms of things that we know or do not know and where we need additional information.

I am going to go through a discussion of the functioning of a nuclear explosion, all the way through, and say what the uncertainties are, where we are, what we know, and what we don't know—that sort of thing.

[A series of slides was shown:]

The current nuclear test program meets our requirements to:

- **Maintain reliability of the stockpile**

[Deleted]

- **Provide warheads for new or modernized systems**
  - **—Improved safety and security**
  - **—Improved system effectiveness for deterrence**
- **Avoid technological surprise**

Dr. BATZEL. We have already talked about the issue of why we need to test, so I think we can just go right on through that.

[Chart deleted.]

NUCLEAR WEAPONS TECHNOLOGY

Dr. BATZEL. This is a schematic of a thermonuclear weapon. [Deleted.] The primary is the initial producer of the energy. Around that primary is wrapped a radiation case. That primary, when it explodes—and I will talk a little further about that—gets very hot, and it radiates like a very hot lightbulb, and that energy is contained by the radiation case. It surrounds the secondary and produces a very high temperature environment, [deleted] and causes that secondary to [deleted] produce most of the militarily significant yield.

The primary is a minor contributor to the total yield.

Senator JOHNSTON. Where is the tritium? Is it in the first bottle?

[Chart deleted.]

Dr. BATZEL. There is tritium inside that primary section. What you see there, in that top picture, is the detonator igniting the high explosive, which is used to compress the nuclear material in that primary. [Deleted.]

We can do those high explosive experiments, using our flash radiography, and we can pretty well define [deleted] looks like at about the time it should explode.

The plutonium, in this case, for example, is compressed. It forms a critical mass. Neutrons are injected into that critical mass [deleted] so that you get a chain reaction, which causes the production of energy. That hot plutonium heats the deuterium and tritium gas, and causes it to burn. That is fusion.

[Deleted.]

NUCLEAR REACTION

Dr. Batzel. The whole physical situation changes after you start the chain reaction, because the temperatures are just fractions of a volt, a few thousand degrees. They become a few million degrees all of a sudden, and the velocities are very high.

It is an area of physics where we cannot do experiments in the laboratory to mock that up. So we have to build mathematical, theoretical models of that interaction, match those models to our experiments, and, hopefully, convince ourselves that we can extrapolate, for example, to the next design, based on those theoretical models.

The time required to implode that primary is about [deleted].

The time that it takes the radiation, the explosion in the primary to go off and the radiation to go down around that secondary, [deleted].

Again, that is a phenomenon which we cannot reproduce in the laboratory; we can only do that in a nuclear explosion experiment.

As you can see, then the secondary is compressed by that primary energy. [Deleted.]

Senator Johnston. [Deleted.]

Dr. Batzel. Yes. The reason you can compress that secondary and get that yield is because you are driving it with a much higher energy source; namely, that fission energy from the primary.

Again, we have to build our mathematical models, our theoretical models, and match it to experiments. We cannot do those kinds of experiments in the laboratory.

Since the militarily significant yield comes from the secondary, it does not help just to do the primary. You have to convince yourself that the secondary is going to go off and give the yield required. Otherwise, you do not have a nuclear explosion which will meet the Department of Defense requirements.

NUCLEAR WEAPON TESTING AND COMPONENT RELIABILITY

So, we really need the full yield to determine yield and yield uncertainty. We do not have that flexibility today for our new strategic systems, [deleted].

So at the 150 kilotons, we are unable to test at full yield the most important of our strategic warheads.

Senator Johnston. Now, you know about the decay rate of tritium, so you don't have to test to determine that—or do you?

Dr. BATZEL. The decay rate of tritium, the deuterium-tritium mixture which is in the primary, the tritium does decay with a 12.3-year half-life, and we know that. [Deleted.]

So, we have to put a limit on the length of time a weapon can remain in the stockpile before we have to put a fresh tritium bottle on it.

Senator JOHNSTON. Well, what I am getting at is this. I know you have to have a nuclear explosion to have a full test. But it is principally to prove your nonnuclear components, like your sensitive high explosives and your other things, that you have to conduct weapons tests, rather than your nuclear components principally; isn't that so?

Dr. BATZEL. No; in fact, it is the contrary.

We can test the high explosive and we know that when we can measure the tritium, we know what the tritium decay is. We can do such nonnuclear experiments.

But the proof of the pudding is whether, in fact, that primary detonation will actually take place so that the radiation flow will occur, whether you compress the secondary and whether you get that yield or not.

[Deleted.]

Dr. BATZEL. We had done the best we could in the nonnuclear areas. Without the nuclear experiment, you do not have the confidence as to whether that explosion will occur as you predict.

Testing verifies crucial performance issues to assure weapon reliability

• **Full yield to determine yield and yield uncertainty**	**Complete weapon**
[Deleted]	
• **Primary performance to assure adequate energy to drive secondary**	**Primary only**

[Deleted.]

Dr. BATZEL. Then you back off and say, "Well, we will just do the primary only." That gives you no insight into whether that secondary configuration was proper, [deleted] or whether, in fact, you are going to get the yield.

Each one of those limiting steps decreases your level of confidence with respect to what you are able to achieve by a nuclear experiment.

If you were to look for a set of materials which you least liked to work with and put them together in a package, you would use high explosives—lithium deuteride, tritium, plutonium, uranium. Put them all together and they are chemically reactive. The high explosives, by nature, because it is a high explosive, degrades with time. The tritium obviously decays. [Deleted.]

And, as you point out, with time we get into trouble.

So, that deterioration can cause problems, even total failure. We have a program where we actually sample the stockpile as a function of time. We pull warheads back out, disassemble them, and physically inspect them to see what changes have occurred.

That is the way we monitor the situation as best we can. Then, it behooves you every once in a while to do that full experiment, to make sure that you have not missed something.

Senator McClure. How much of the total testing program is involved in the actual explosive of a current stockpile weapon?

Dr. Batzel. [Deleted.]

Senator McClure. Thank you.

Dr. Batzel. May I have the next slide, please.

[Chart deleted.]

Dr. Batzel. Let's go back over that discussion again, now.

For the complete weapon—let's talk about the Trident II, for example. The full yield is about [deleted] kilotons. [Deleted.]

At the 150 kiloton area, we are able to test the primary plus some of the secondary components, and that is very important to us. And we are able to meet the existing military requirements by testing at the 150-kilotons level. But if you take that flexibility away, then our confidence begins to decrease rapidly.

Senator Johnston. But you have tested Trident II, haven't you?

Dr. Birely. [Deleted.] So we are almost there, but not quite.

Senator Johnston. [Deleted.]

Dr. Birely. Right. [Deleted.]

[Deleted.]

Senator Johnston. [Deleted.]

Dr. Batzel. [Deleted.]

Senator Johnston. As you point out, all of these warheads you redesign for longevity and all of that, as time goes on. So your Trident II, even if fully tested for its present generation, might be reconfigured in future years to give you a better explosion or a greater longevity or new improvements, whatever?

NUCLEAR WEAPON SAFETY

Admiral Foley. For example, specifically on that one, Trident II does not have insensitive high explosives. So you need to look at it to see if downstream sometime you could put a block change or a block fix in.

Senator Johnston. Trident II does not have insensitive high explosives?

Dr. Birely. No; you have to look at the tradeoffs on military effectiveness.

We optimize overall systems costs and effectiveness, and that generates limitations of weight, mass, and volume.

Because the insensitive high explosive is inherently less sensitive, you need to put more of it into a nuclear device so that when you detonate it, when you want it to go off, it gives enough energy to compress the system.

Had we used the insensitive high explosive, the weapon would have weighed more and, therefore, for a given missile, we would either have had less range on the reentry body or less warheads per missile.

So, the tradeoff was done. It was felt that for overall military effectiveness, the use of the conventional, more sensitive high explosive was the better way to go.

Senator JOHNSTON. Well, as long as the submarine does not shake too much, then it is all right.

Dr. BATZEL. One worries about those kinds of things.

Senator JOHNSTON. Well, now, please tell me not to worry too much. [Laughter.]

Dr. BATZEL. Oh, I am not worried too much. [Laughter.]

Dr. BARKER. The entire history of the submarine fleet has been with the sensitive high explosive that is in the Trident II. It has only been in the last 10 years that they have been putting insensitive high explosives into the stockpile. In fact, it is only in the last 6 years that we have really started to produce it at a significant rate.

Today, the Department of Energy has enabled us to put insensitive high explosives into [deleted] of the stockpile.

So, [deleted] of the job is done. Ultimately, we would like to have insensitive high explosives——

Senator JOHNSTON. I mean, the submarines are everywhere.

Dr. BARKER. The submarine is one class of weapon, strategic weapon, where we do not yet have insensitive high explosives. Dr. Birely just explained why that decision was made.

Senator JOHNSTON. Well, [deleted] that you do have is in Minuteman, then?

Dr. BARKER. Well, no; in MX. Minuteman is an old enough system that insensitive high explosives did not even exist when Minuteman was designed. So we are talking about the MX, we are talking about GLCM's and Pershing II's. Those are the systems that now have insensitive high explosives.

TRIDENT II

Senator JOHNSTON. And you do think you can retrofit Trident II?

Dr. BARKER. As long as we can test.

Admiral FOLEY. We are looking at it.

Dr. BARKER. This replacement, as Dr. Birely has pointed out, is not simply a matter of stripping off the sensitive stuff and putting the insensitive on it. It is a total redesign, and we would need to do a nuclear test to make sure that this redesign would work.

Senator JOHNSTON. Well, not to make too much of this, you say that you don't worry too much.

Would the worry be reliability or the fact that the whole thing could blow up.

Dr. BATZEL. [Deleted.]

Senator JOHNSTON. But only the HE?

Dr. BATZEL. When the HE goes off, it blows up the plutonium, and it would scatter it everywhere. That is both a real problem and——

Senator JOHNSTON. But the physics would not give you a thermonuclear explosion?

Dr. BATZEL. You won't get a nuclear yield. Our weapons are all designed so that in the case of an accident, you will not get a nuclear yield.

Admiral FOLEY. But you are going to blow a heck of a hole in the submarine.

Dr. BARKER. Let me say that this was a very difficult question for the Defense Department. It really was a defense requirement which drove the decision that was made. The Department of Defense established a requirement for yield, weight, and diameter for this reentry vehicle, and it turned out that those criteria could not be met using insensitive high explosives.

So, we had the choice of [deleted] allowing the reentry vehicles to grow in size to incorporate insensitive high explosives, or to go forward with the kind of high explosive that has been used for decades, literally, throughout most of the stockpile.

The other factor that was relevant is the fact that the propellant on the Trident is a very high energy propellant, and the configuration of the third stage is such that the third state runs right up the middle, between the warheads. That motor propellant itself is a very, very high energy object. In fact, some studies indicated that, even had we put insensitive high explosives on there, in some kinds of accident situations the explosive force of that third stage motor would be sufficient to scatter plutonium around anyway.

So, we balanced all these factors. We can be second guessed that we should have made a different decision, but this is the one that we did make.

Dr. BIRELY. While we are on this topic, although there have been some of these accidents where the explosive went off, we have a perfect record on nuclear safety; there has never been an unintentional nuclear explosion, even in those accidents where a high explosive was detonated.

Admiral FOLEY. One of the things we have to very carefully look at is this. As the missile systems are developed now, the propellant that is in there is becoming increasingly unstable, if you will—a hotter propellant going on in there, while we are working them into warheads themselves as safe as possible. So you have a dichotomy on them which needs to be looked at very carefully. We are doing that now.

Dr. BATZEL. May I have the next slide, please.

Senator DOMENICI. May I ask a question, Mr. Chairman?

Senator JOHNSTON. Yes.

Senator DOMENICI. While you have just mentioned that we have never had the kind of accident you have described, it is true, is it not, that in terms of the allocation of resources to go back into the older systems and constantly assess safety has primarily been driven by the labs themselves insisting that it be done.

Is that a fair statement?

Dr. BIRELY. That has been a very important part of it; yes, sir.

Senator DOMENICI. If you want to strike the word "primarily" out of that, OK. [Laughter.]

Now, I am not critical, but when they have their choice of money and they are moving on to new systems, they have to constantly be reminded to go back and make the old ones as safe as possible.

Is that a fair statement?

Dr. BIRELY. I think I will let the representative of the Department of Defense respond.

NUCLEAR WEAPONS SAFETY

Dr. BARKER. I snuck in here, Senator, without your knowing it.

I am the Assistant to the Secretary of Defense for Atomic Energy. I think your thrust is exactly right.

The safety of nuclear weapons is a shared responsibility between the Department of Defense and the Department of Energy. I think the country has benefitted from the fact that both Departments are very heavily involved. If the Defense Department slips up a little bit, the Department of Energy is there to remind us of what our responsibilities are, and maybe sometimes vice versa.

It is a true partnership as far as nuclear weapons safety is concerned.

NUCLEAR TEST BAN LIMITATION

Senator DOMENICI. Could I just ask one other question with reference to the general level of debate in this country with reference to test ban limitations and treaties?

I wonder if you might, in just a couple of sentences—I don't want a big dissertation on this—tell us, as you view the national debate on the need for testing, the various proposals with reference to test bans, have you concluded that there is a great risk that much of the public discussion is missing the point?

Dr. BIRELY. I certainly think it is, Senator.

I happen to read that statement at the time it was made, and disagreed with it for the reasons that the two witnesses have talked about already.

NUCLEAR TESTING AND STOCKPILE CONFIDENCE

Continued testing is absolutely essential to retain confidence in the stockpile that it will work, as the laboratories have indeed certified that it will.

The reason that is so important is because we rely on the stockpile for deterrence which, of course, has avoided nuclear war for 40-some years.

Without the ability to test, that confidence would decay with time, and, in my view, lead to a substantially less stable situation than we have now. It would probably require enormous additional investment in other areas, such as conventional forces, in order to retain an overall deterrence.

Indeed, if the confidence in the stockpile decayed in terms of confidence in individual weapons, you would probably buy more weapons so that your overall confidence in your stockpile would go up in a military mission.

Admiral FOLEY. Let me speak as one who was a former military commander. I would say the same thing. I would support what has just been said.

My confidence in those weapons deteriorates as time goes on without being able to test them.

If I were going to launch those at an enemy, I would be tempted to use two rather than one, because I am not very sure about the first one. So the instability causes my confidence level to deteriorate and creates a need for additional weapons.

I get upset about flip statements or casual statements that are made about nuclear weapons. I am never comfortable around nuclear weapons, nor do I think there is a lot of humor with them. We do a disservice to the citizens of the country when we address it in that kind of light.

Senator JOHNSTON. We are running behind so why don't we finish your statement Dr. Batzel. Let's try to limit our questions just to the matter that the witness is covering.

Then we will come back and deal with the overall questions.

CONFIDENCE AND RELIABILITY PROBLEMS

Dr. BATZEL. May I have the next slide, please.

Since 1963–64 one-third of stockpiled weapons have depended on continuation of nuclear testing following deployment

W45 (TERRIER)
W47 (POLARIS)
W68 (POSEIDON)
W79 (AFAP)
W84 (GLCM)
B28 (BOMB)
B43 (BOMB)

[Deleted]

W44 (ASROC)
W50 (PERSHING)
W52 (SERGEANT)
B57 (BOMB)
W59 (MMI)
B61 (BOMB)
W80 (ALCM)

This is a listing of those problems which I think we have discussed. They are examples of the problems we have had with deployed systems, where we have actually had to go back and use a nuclear test to correct that situation.

[Next slide, please.]

[Chart deleted.]

Dr. BATZEL. I want to spend a little time on a model which I have.

This is the W–68 Poseidon warhead. [Deleted] deployed on the Poseidon. We had a problem with that system.

You can see pictures of the high explosive there, on the right-hand side, and while that discoloration does not look like much, what happened was this. The products exuded by the high explosive interacted with the little detonators in the primary.

Behind you, there is a model of the W–68. This [indicating] is the primary. It is not really plutonium. It is a mockup. [Deleted.]

This [indicating] is the secondary. [Deleted.]

When the high explosive began to exude this material, it attacked a little [deleted] bridgewire. [Deleted]. The consequence of losing that little bridgewire in there is that not even the HE will go off if that little bridgewire is gone, because a high electrical current is sent through that little bridgewire, which makes it very hot. That starts the detonators, which then drive the primary, which produces the yield.

That happened about 4 years after we had conducted a major series of tests on this particular system. In fact, we had over 40 experiments related to the development of this modern system—not modern today, but modern technology at that particular time.

So, 4 years later, we found we had a problem. In those series of nuclear tests that we had conducted, we had tested this configuration with a different kind of high explosive.

This we call the LX–09 and the new explosive we call LX–10. It has a different binder; it does not suffer from the same kinds of problems. So we were able to make that substitution.

We had had the previous test. We were confident that we knew what the yield of that primary was going to be, except it gave about 80 percent of the yield we had expected. So we were able to modify the situation.

But, again, it illustrates the point that if you want to have high confidence in your system, you had better test it.

May I have the next slide, please.

[Chart deleted.]

Dr. BATZEL. This is a plot of the secondary yield as a function of primary yield. If you add those two together, it is in principal, the total. As you can see, there is a precipice beyond which you do not want to go in terms of letting that primary yield get too low because, if it gets too low, the secondary will not detonate. You will not get the yield.

So, we were surprised by the yield of that particular experiment. The primary yield was low. We were able to adjust that. [Deleted.]

This particular slide I think we will spend a few minutes on.

[Chart deleted.]

IMPACT OF NUCLEAR TEST YIELD LIMITATIONS

Dr. BATZEL. On the left is the number of strategic systems, as a function of yield. The question is what fraction of our strategic systems can we test as a function of yield. [Deleted.]

That is the way the yield limitation would affect our ability to indeed provide warheads to meet Department of Defense requirements.

Admiral Foley. So there are already significant restrictions on it.

Stockpile maintenance under increased testing restrictions

- **Continue to maintain high degree of reliability**
- **Increase emphasis on life extension of existing seapons**

[Deleted]

Dr. Batzel. In terms of our history, [deleted].

Senator DeConcini. Can you be any more definitive on likely or moderately likely?

Dr. Batzel. Well, most of the problems we have had in the stockpile [deleted].

Senator DeConcini. What percent?

Dr. Batzel. Essentially all of them [deleted].

Senator DeConcini. All of the problems [deleted]. I see.

Dr. Batzel. [Deleted.]

Senator DeConcini. These weapons systems—it varies as to the percentage of problems [deleted]; is that correct?

Dr. Batzel. Yes.

Admiral Foley. We can say that we have had problems with one-third of the weapons that are in the current stockpile.

Senator DeConcini. They will have problems period?

Admiral Foley. Have had problems.

Senator DeConcini. [Deleted.]

Dr. Batzel. Most of them were [deleted].

Admiral Foley. That is right.

Dr. Batzel. [Deleted.]

So we have had some of those kinds of problems.

Dr. Barker. Roger, I would like to point out that the viewgraph does not contain the words that you said.

[Deleted] what Dr. Batzel said was that the testing requirement requires you to test the whole weapon because you want to find out how [deleted].

Dr. Batzel. Absolutely.

Dr. Barker. That viewgraph can be read as implying [deleted].

Dr. Batzel. I certainly did not intend that, of course.

May I have the next slide, please.

[Chart deleted.]

Dr. Batzel. [Deleted.]

What you see here is our prediction of the primary yield, and then the measured yield.

We checked it hot and cold, and our highest confidence should have been the ambient temperature, essentially room temperature. [Deleted.]

The next slide, please.

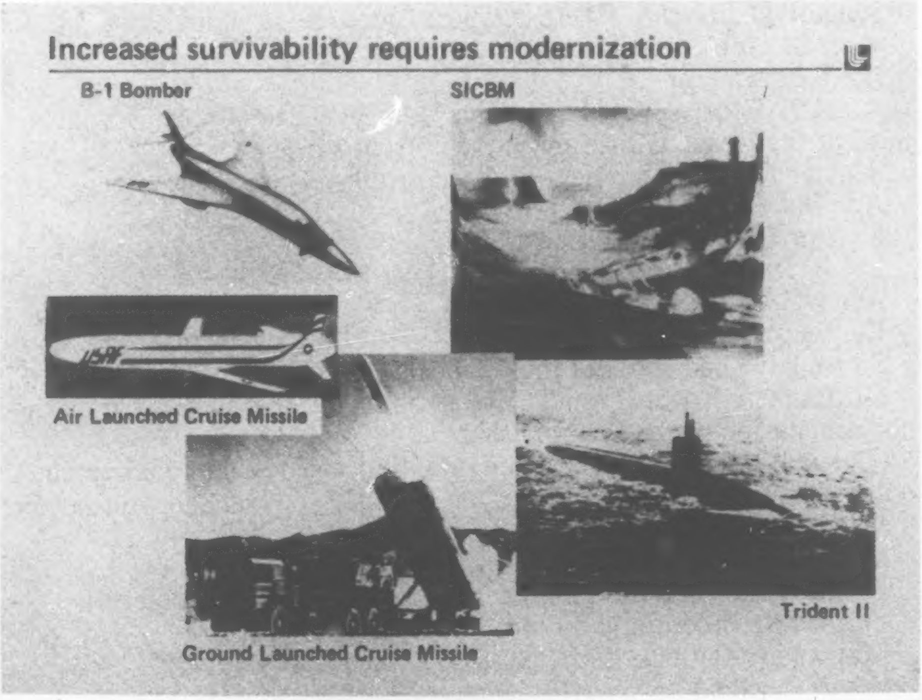
Why do we develop new nuclear warheads?

- Delivery systems change
- Requirements change
- Technology improves
  - —Military effects
  - —Collateral effects
  - —Safety
  - —Security
  - —Maintenance
  - —Operational ease

NUCLEAR WEAPONS DEVELOPMENT REQUIREMENTS

Dr. BATZEL. The question of new nuclear warheads, delivery systems change, requirements change, technology improves, safety, which we have discussed, security, maintenance, military effects—all are shown.

Next slide, please.



Increased survivability requires modernization

B-1 Bomber
SICBM
USAF
Air Launched Cruise Missile
Trident II
Ground Launched Cruise Missile

MODERNIZATION AND SURVIVABILITY

Dr. BATZEL. For the B-1 bomber, we needed a lay-down bomb, which would allow the bomber to come in at low altitude, lay that bomb on the ground, and then have the bomber escape before the warhead goes off.

With the air-launched cruise missile, again, it is a question of designing a warhead with insensitive HE, which will provide the maximum range possible.

The small ICBM, again, has to be designed to withstand the environment.

The ground-launched cruise missile is the same kind of situation.

Then, of course, you see the Trident II.

These are examples of new systems which require modernization of warheads.

Next slide, please.

[Chart deleted.]

HIGH EXPLOSIVE SAFETY

Dr. BATZEL. When we talk about the insensitive HE, and we have talked about it, this is a mockup of the MX warhead in its environment, if there were an explosion of the rocket.

This is the third stage of the missile. Mounted on that is an RV, which is a mock warhead. It has everything in it except the plutonium. The third stage was ignited. We were able to recover the insensitive HE. It had not gone off.

The plutonium would have been contained [deleted] and would not have released radioactivity to the environment.

This is why it is important to have this kind of flexibility in our next military systems, to prevent that possibility from happening.

The next slide, please.

[Chart deleted.]

Dr. BATZEL. To illustrate the fact that it is a real world out there, this is the B–52, with a fuel fire in North Dakota, at Grand Forks. [Deleted.]

The wind happened to be blowing down the axis of the airplane.

[Chart deleted.]

Had the wind been blowing across, rather than parallel to the fuselage, that whole system would have been engulfed in flames. [Deleted.]

Senator JOHNSTON. How far out was that?

Dr. BATZEL. Oh, out 20 miles. It would be all over the place.

If you think about why you really need that insensitive high explosive, I don't think you would need a better example than looking at that one [indicating]. There is a real world out there and those kinds of accidents do happen. I don't know what the consequences of that would be.

It would be very difficult to put any weapons on any airplane, anywhere, I think.

Senator JOHNSTON. Now, that would have been plutonium? Would that have been anything radioactive?

Dr. BATZEL. There would not have been any nuclear yield.

Dr. BARKER. Plutonium inhalation is indeed a [deleted] cancer producer.

Dr. BATZEL. It is something you don't want.

Senator JOHNSTON. Well, I mean we are not talking about a Chernobyl there.

Dr. BATZEL. You are talking about something that in one respect could be probably worse than Chernobyl.

Senator JOHNSTON. Is that right?

Dr. BATZEL. Yes; because you have plutonium in the soil and on the soil, which you have to clean up. I am not sure which I would rather trade for. I don't want either one.

Senator DECONCINI. That particular fire created enough heat, then, that it would have caused this?

Dr. BATZEL. Yes; the aircraft burned for hours.

Admiral FOLEY. The wind was blowing from tail to nose.

Senator DECONCINI. What kind of heat do you have to have? I thought you had to have a greater heat than just a fire in order to ignite the stuff. Is that not true?

Dr. BATZEL. It is true of the insensitive HE. It will only burn; it will not explode.

But the sensitive high explosives which are in those particular warheads would have detonated. It would have happened in that environment.

Senator DECONCINI. Do you know that through testing?

Dr. BATZEL. Yes, sir.

Senator JOHNSTON. Now, you have those retrofitted B–52's?

Dr. BATZEL. Not yet.

Dr. BARKER. This is one of the tragedies, I think, one of the great misunderstandings about the DOE budget.

The Department of Energy budget is the budget that produces insensitive high-explosive designs, and we have had requirements for insensitive high-explosive bombs. The B–61 and B–83 are designed weapons. The B–61 and the B–83 are in production. We have a SRAM A right now. We are just about to start, we hope, on engineering development of the SRAM II.

The SRAM II will have insensitive high explosives in it. We still have not gotten the go-ahead to proceed with construction of the SRAM II design, for full-scale engineering with ultimate production.

When the DOE budget gets squeezed, the priority always goes to the strategic missile systems. So MX and Trident get the priority. The things that get pushed off and delayed are the bombs and the tactical theater systems.

This has resulted in the delay of implementing insensitive high explosives into the stockpile.

All of these things are necessary. I am not suggesting any complaint about the priority. I am just saying that when those squeezes happen, we put off the procurement of systems where insensitive high explosives and improved security features are all critical components that we need, and nuclear testing is critical so that we can introduce these features into the stockpile.

Senator JOHNSTON. Let me ask you this.

Before you finish your presentation, Dr. Batzel, would you deal with what I think is a very central question here, the question of the symmetry of test bans.

I think you make a very strong case for the need to test.

Now, to what extent does a test ban of whatever kind or nature impact on us unevenly from that of the Soviets, or even if it impacts evenly, why would that be an advantage to the Soviets, or why would it be unwise to have a test ban of whatever kind and nature, if you feel that that is so?

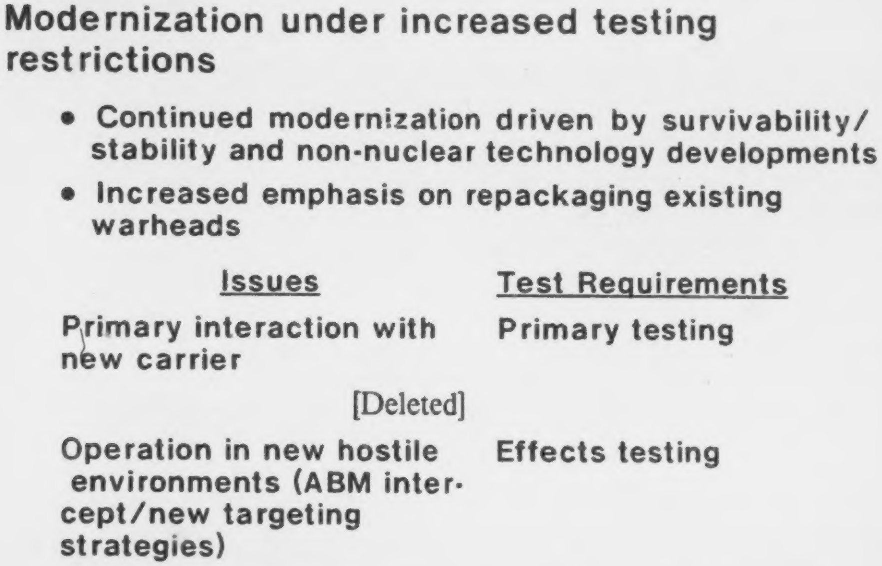
I do not want to interfere with your presentation.

Dr. BATZEL. Yes; I am going to come to that.

Senator JOHNSTON. OK; good.

MODERNIZATION UNDER TESTING RESTRICTIONS

Dr. BATZEL. We talk about modernization of the stockpile under increased testing restrictions.



Modernization under increased testing restrictions

- Continued modernization driven by survivability/stability and non-nuclear technology developments
- Increased emphasis on repackaging existing warheads

Issues	Test Requirements
Primary interaction with new carrier	Primary testing
[Deleted]	
Operation in new hostile environments (ABM intercept/new targeting strategies)	Effects testing

Dr. BATZEL. One has to recognize that when you put that warhead on a different configuration, you have to worry about all of the things that are around it. You have to make sure, if you are not allowed to test it, you are going to want a large volume around it. You are going to want to make sure that you have not put anything up next to it, which can disrupt the functioning of the nuclear warhead.

May I have the next slide, please

[Chart deleted.]

REPACKAGING EXISTING WARHEADS—PERFORMANCE CERTIFICATION

Dr. BATZEL. [Deleted.]

So, just saying we will put it in another package is not straightforward.

One has to be very careful about that. You would feel a lot more comfortable if you were able to test that configuration, even given that you have standoff room and all the test.

Next slide, please.

[Chart deleted.]

ROBUST WEAPON DESIGNS

Dr. Batzel. We talk about robust weapons design. That is a direction which we feel the Soviets have taken.

They have more throw-weight. Their RV's are larger. The best we can tell they do not package them and integrate them so well into the RV configuration. [Deleted.]

[Delete chart.]

[Deleted.]

Admiral Foley. [Deleted.]

Dr. Batzel. Yes, and probably twice the amount of nuclear material.

So, what that says is we believe they have gone to these robust designs so that their need for tests, their need for experiment is less than ours.

Senator Johnston. What do we use this on?

Dr. Batzel. The 12A?

Senator Johnston. Yes.

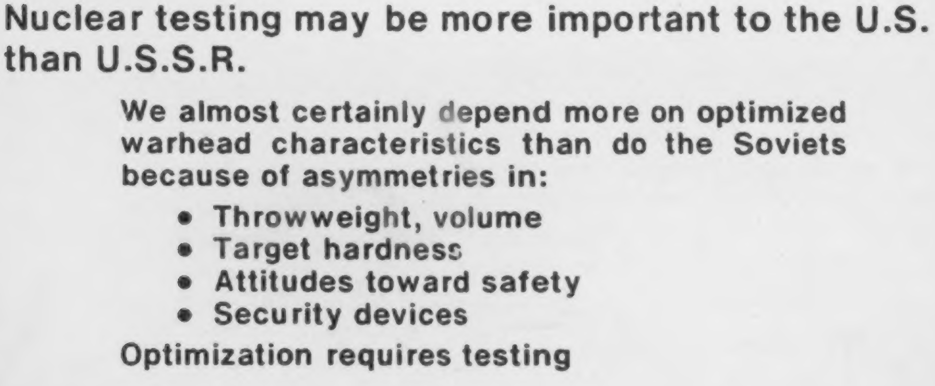
Dr. Batzel. That is Minuteman III.

Senator DeConcini. Why is there a need for testing less because they use more when they do not get much more out of it? They do not get more out of it, as a matter of fact. I do not understand.

It would seem to me that if you had more mass and more space, and what have you, you would have more opportunity to have more leaks or something that did not work, where if you had it smaller, where it was functional, it would be different.

Dr. Batzel. [Deleted.]

Next slide, please.



Nuclear testing may be more important to the U.S. than U.S.S.R.

We almost certainly depend more on optimized warhead characteristics than do the Soviets because of asymmetries in:

- Throwweight, volume
- Target hardness
- Attitudes toward safety
- Security devices

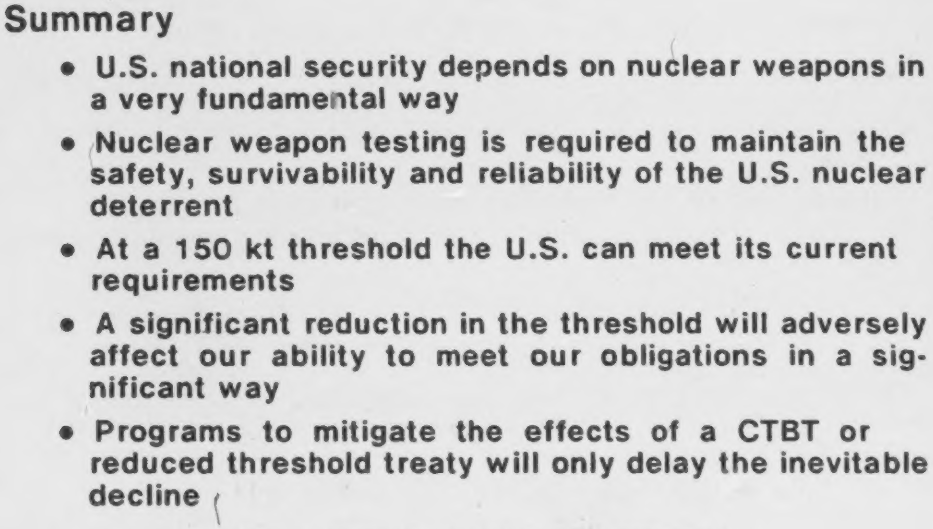
Optimization requires testing

NUCLEAR TESTING—UNITED STATES AND SOVIET NEEDS

Dr. BATZEL. Our conclusion is that we almost certainly depend more on optimized warhead characteristics than the Soviets do. Throw-weight, target hardness, that issue of attitudes toward safety—our view, based on what we can see, with Chernobyl as an example, is we are not so sure that they worry so much about safety and security. They have a different security system.

Our kind of optimization really requires testing.

Next slide, please.



Summary

- **U.S. national security depends on nuclear weapons in a very fundamental way**
- **Nuclear weapon testing is required to maintain the safety, survivability and reliability of the U.S. nuclear deterrent**
- **At a 150 kt threshold the U.S. can meet its current requirements**
- **A significant reduction in the threshold will adversely affect our ability to meet our obligations in a significant way**
- **Programs to mitigate the effects of a CTBT or reduced threshold treaty will only delay the inevitable decline**

NUCLEAR TESTING AND NATIONAL SECURITY

Dr. BATZEL. This is the summary. U.S. national security depends on nuclear weapons in a very fundamental way. It is required to maintain the safety, survivability, and reliability of the U.S. nuclear deterrent. At the 150-kiloton threshold, we can meet our current requirements.

Suffice it to say, there are requirements that could come along which we may not be able to meet because of that constraint.

A significant reduction in this, anything below the 150 kilotons in the test threshold, will adversely affect our ability to meet our obligations in a significant way.

Programs to mitigate the effects of a CTBT or a reduced threshold will only delay the inevitable decline in our confidence in the stockpile.

When you go back to that viewgraph [deleted]. I think it is very important to remember that 150 kilotons is important to the United States, given its choice of strategic warheads.

[Chart deleted.]

Admiral FOLEY. I would ask you to take a careful look at this slide. I think this is the most important viewgraph that we have in the whole presentation. We should focus on this.

What you can do at 150 kt and what you cannot do at 50 kt or 10 kt is important. It points out the restrictions that already exist on the stockpile at 150 kt. It is not as though we are talking about the initial restrictions that are being placed on nuclear testing or development in the United States. There are significant restrictions that already exist. We are hanging in there by our fingernails in terms of the present stockpile. This is what happens as we start marching on down from that. It is very, very important.

Dr. BATZEL. Senators, that completes my comments.

STATEMENT OF JOHN H. BIRELY, DEPUTY DIRECTOR FOR DEFENSE, LOS ALAMOS NATIONAL LABORATORY

ACCOMPANIED BY JOHN C. HOPKINS, ASSOCIATE DIRECTOR FOR WEAPONS TECHNOLOGY, LOS ALAMOS NATIONAL LABORATORY

Senator JOHNSTON. Did you want to add to that, Dr. Birely, or are you all ready for questions?

Dr. BIRELY. I have a statement for the record, sir.

[Delete chart.]

Senator JOHNSTON. All statements will be printed in the record.

Dr. BIRELY. If you don't mind, I would just like to summarize it very briefly.

Senator JOHNSTON. All right, proceed.

NUCLEAR WEAPONS EFFECTS TESTS

Dr. BIRELY. The previous witnesses have talked about several of the needs for nuclear testing. There are two more important ones that I just want to go over briefly.

One is the need to do what we call nuclear weapons effects tests, where we subject our military systems to the cleverly prescribed and clearly controlled output of nuclear devices, so that we can understand the vulnerability of our systems to the other side's nuclear weapons and understand the lethality of our own.

These tests are done by the Department of Defense, the Defense Nuclear Agency. The laboratories provide the nuclear weapon.

There is one very important analogy between these experiments and the other nuclear testing experiments that you have heard today. In the Nuclear Weapons Effects Program, we have a very vigorous aboveground simulation program, active computational capabilities. But, none-the-less, when we do these underground explosion tests, every major U.S. strategic system, except Minuteman II, has led to a major surprise that needed redesign and retesting.

So, we just do not have the ability to do those effects tests without nuclear explosions.

Second, those tests are constrained under the Limited Test Ban Treaty, so that, for instance, bulk scale effects, such as high-altitude EMP, could not be simulated underground, and we cannot test our nuclear weapons against hardened targets of the kind the Soviet Union is now putting out there.

A final and very important reason to continue to do nuclear testing is to avoid technological surprise.

The United States and its allies rely very heavily on our technological advantage to overcome geographical and numerical strengths of the Soviet Union. It is a key responsibility of the nuclear weapons labs to make sure that the technology of nuclear weapons and what is actually possible is always evaluated.

That is one of the major reasons why we were engaged in issues of nuclear-directed energy prior to the beginning of the SDI program.

[Deleted.] So, without testing, I do not believe we could understand what the potential effects of those systems would be on our military hardware if the Soviets were able to employ them.

That is the kind of technological surprise we just have to avoid.

IMPACT OF TESTING CONSTRAINTS

Let me just make a few remarks on the impact of additional testing constraints.

First of all, testing constraints do not remove the responsibilities from the design laboratories that we already have today. We would still be responsible for making sure that the stockpile was designed well and, in particular, to help maintain it by providing judgments when problems came up as to how to fix those problems so that the devices would work.

It is the policy of the U.S. Government that further testing constraints should come along only in step with further arms control negotiations and arms reductions, so that the need for testing would decline only as the number of weapons declined.

In particular, testing constraints will do nothing about eliminating the number of nuclear weapons. It would not do anything to change the Soviet threat. It would not do anything toward achieving a better balance of conventional forces, and it would do absolutely nothing to control other threats, like chemicals and biological warfare.

Let me make a few remarks on experience in the United States during 1958 to 1961 when we, the Soviet Union, and the United Kingdom did engage in a moratorium.

During that period of time, the United States found several safety problems with weapons in its stockpile that it could not fix without additional testing. So operational constraints were put in.

After the moratorium was over and we started doing tests again of things that had gone into the stockpile, we had a number of surprises. In particular, a number of weapons that we were reasonably confident would work well and that were deployed during the moratorium failed to work at all when we tested them.

Had the moratorium not ended, we never would have understood that these systems were defective, and we would have had false confidence in the deployed systems.

There were other events after the moratorium where we, by physical inspection, found flaws in the weapons that were visually available. In those cases, probably without testing we would have pulled those weapons from the stockpile.

It turned out that these optically visibly damaged things did not affect the performance of weapons, and we could only tell that by testing.

So there are cases where we would have been unnecessarily pessimistic about the stockpile were we unable to test.

These problems with the stockpile prevail today. We have heard a number of times the statement that one-third of our designs that we have fielded have had problems. We have heard that we have been able to deal with those by having the ability to test after deployment.

If we, for instance, had a kiloton threshold, there is no way that we could have dealt with those problems. Many of them could not have been found. Many of them could not have been fixed. The result would have been an increased lack of confidence in the stockpile.

We certainly cannot prove that there will be problems like this in the future. I think, however, all we can do is rely upon our past experience, rely upon the judgment of others.

I would remind you that, prior to the last launch of the space shuttle, the Thiokol engineers pointed out what they considered to be some potential problems. They were asked by senior management if they could prove that there would be a problem. The engineers said "No," and the decision went ahead to launch the space shuttle.

I would like to close by reminding you of a quote from Andrei Sakharov, who recently made the observation that the question of nuclear testing is not critical for restraint of the nuclear arms race. "As long as nuclear weapons exist and they are not banned, the decision regarding underground testing is the internal, sovereign affair of each nuclear power. Eliminating the issue of a comprehensive nuclear test ban will facilitate negotiations on more urgent problems of disarmament."

I certainly agree with that statement.

Let me close by saying that we have met the military requirements over the last decade with a threshold test ban limit of 150 kilotons. We do exploit pre-TTBT technology and, therefore, pay a price in doing this. But we are reasonably optimistic that in the future, we will be able to continue to meet these new requirements.

I would say that if significantly lower thresholds were imposed upon us, our optimism would be extremely difficult to sustain.

Thank you.

[The statement follows:]

STATEMENT OF JOHN H. BIRELY

It is a privilege to be here. I hope to bring to the attention of the Committee several considerations from a technical point of view, reflecting my own responsibilities and experience, that bear on the issue of nuclear testing. Admiral Foley and Dr. Batzel already have covered a number of related subjects, and my intent is to complement their statements. First, I will discuss a key analogy between nuclear effects testing, generally the responsibility of the Defense Nuclear Agency, and the kind of nuclear weapons tests for which we in the DOE complex are responsible. Second, I will touch briefly on the key issue of technological surprise. Finally, I will discuss the risks that would result from nuclear testing constraints beyond those already in place.

NUCLEAR WEAPONS EFFECTS TESTS

In addition to the performance and safety of our nuclear weapons throughout their stockpile life, it is necessary to understand fully their effects on potential targets (lethality), and the vulnerability of our weapons to possible countermeasures. Both of these areas are studied in what we call nuclear weapon effects tests. While these are mainly a Department of Defense responsibility, they require considerable DOE and nuclear weapons laboratory support and participation. In nuclear effects tests, weapon subsystems, such as re-entry vehicle (RV) components or post-boost modules, are exposed to a carefully designed combination of x-rays, gamma rays and neutrons that simulates the threat environment of concern. The source is usually a comparatively low-yield nuclear device chosen to produce the desired flux characteristics. These nuclear weapon effects tests have two things in common with other nuclear weapons tests. First, they invariably are preceded to the greatest extent possible by non-nuclear tests, as well as by theoretical calculations, in order to minimize the number of nuclear tests as well as to provide as much assurance as possible that the nuclear tests will succeed. Second, and in spite of the first point, when the nuclear effects tests have been done, they have in almost all cases resulted in disagreeable surprises: the discovery of significant problems that the calculations and non-nuclear tests were unable to discern.

The critical points are the following:

> Every U.S. strategic missile system except the Minuteman II reentry vehicle has experienced surprises in underground nuclear effects tests. Unexpected results persist even in the most modern systems.
>
> Most of the surprises require redesign and retest, some repeatedly, in order to achieve the level of survivability that our intelligence estimates tell us will be necessary.
>
> The surprises occur in spite of extensive analytical and non-nuclear simulation test programs. This fact, as we shall see later, is precisely analogous to the experience we have had in other areas of nuclear weapons testing: no amount of calculation and non-nuclear testing can replace actual nuclear tests.

The kinds of effects tests used to evaluate the survivability of U.S. weapons can generally be accomplished effectively underground, and as already noted, usually with fairly low yield explosions. In other areas, involving such macroscopic effects as high-altitude electromagnetic pulse generation (EMP), or energy coupling into hard targets, we are severely restricted by the Limited Test Ban Treaty of 1963. In these areas, we simply do the best we can underground to understand these phenomena, along with effects on such systems as satellites and command, control, communications and intelligence, or C^3I.

The key point I want to emphasize here is the fact that, thus far, no amount of calculation and/or simulation of nuclear effects has been able to replace actual nuclear testing either as a means of discovering serious problems with our nuclear weapons systems, or later as a means of confirming that they have been dealt with successfully.

AVOIDING TECHNOLOGICAL SURPRISE

The United States and its allies depend heavily on our technology to offset geographical and conventional force advantages of our potential adversaries. The nuclear weapons laboratories have a key responsibility in this area. We must provide the far-out thinking that avoids surprises of the kind that have been seen in the past. Hitler, we know, was moving toward an atomic weapon and did exploit advanced technology in the V1 "buzz-bomb" and the ballistic V2 rocket. On the other side, radar played a critical role in the outcome of the Battle of Britain. Sputnik caught the free world completely off guard.

More recently, additional nuclear weapons phenomena, such as the high-altitude EMP already mentioned, have emerged as serious problems to be dealt with. And the main role of our research on nuclear directed energy weapons (NDEW) is avoidance of surprise in this area, where the Soviets may have long had a massive effort.

It is only by continued concentrated efforts in the areas both of theory and advanced computation, and both non-nuclear and nuclear experiments, that the cutting edge of our technology can be maintained and further technological surprise avoided. This consideration leads me to my main focus: the risks inherent in further restrictions on underground nuclear testing.

IMPACT OF ADDITIONAL NUCLEAR TESTING CONSTRAINTS

Let me note first that test constraints do not relieve the nuclear weapons laboratories of their primary responsibilities of designing and helping to maintain safe, secure, reliable and effective nuclear weapons in response to U.S. military and foreign policy requirements. Andrei Sakharov recently observed that ". . . the question of nuclear testing is not critical for restraint of the nuclear arms race. . . . As long as nuclear weapons exist and are not banned, the decision regarding underground testing is the internal, sovereign affair of each nuclear power. . . . eliminating the issue of a comprehensive nuclear test ban will facilitate negotiations on more urgent problems of disarmament." I share this view completely. Limitations on testing beyond those already in place would have a severely adverse effect on our ability to meet the responsibilities assigned to us, including that of avoiding technological surprise. At the same time, they would accomplish nothing toward elimination of nuclear weapons, achieving balanced non-nuclear forces, and controlling other threats such as chemical and biological weapons.

Nor would further limitations make a qualitative difference in the nuclear threat itself; a little-known fact that illustrates Sakharov's point, for example, is that the critical tests that provided the basis for the nuclear weapons now deployed in multiple independently targetable reentry vehicles (MIRVs) and cruise missiles, were accomplished by the U.S. in 1958, before the 1958 - 1961 nuclear testing Moratorium. Advances since then have primarily been in adaptation of new effective weapons to specific delivery systems (where the U.S. is severely constrained compared with the Soviet Union), and in safety, security and economy.

The Moratorium, in fact, occured just at the advent of the era of light U.S. ballistic missiles that made smaller nuclear weapons mandatory, weapons that depend critically on the so-called boosting technology that had just been invented. It also marked the beginning of great sensitivity to small changes in design and/or construction of nuclear weapons, of vulnerability to aging problems, and of increased reliance on the judgment of nuclear weapons scientists and engineers, validated by nuclear test results, during the weapons' entire lifetime. The military characteristics (MCs) of U.S. weapons are in large part driven by decisions regarding delivery systems that were made in the late 1950s; the Soviets clearly made different decisions about their ICBM forces, and they may well be dependent on less finely-tuned and sensitive nuclear weapon designs. Our military requirements, in addition, are forced to respond to a large number of Soviet actions outside the nuclear weapons area (e.g., dispersal, hardening), that are not restricted by any arms control process. Finally, we believe that the safety requirements that are paramount for the U.S. may be of lesser importance to the Soviets. Thus it is dangerous to mirror image in assessing our needs for continued testing.

Recognition of the problems resulting from our severe weight and size limitations and our very strict safety criteria came only slowly, and largely only after testing resumed. In fact, most of the problems we discovered after the Moratorium would not have been recognized if nuclear testing had not resumed. We thus encountered technological surprise in a particularly malevolent form. If testing had not resumed, the result would have been false confidence in many of the weapons on which our security depended.

This pattern has continued. We continue to discover a problem about every two years as a result of continued underground nuclear testing. Similar discoveries occur, of course, in connection with any high-technology product; consider, for example, recalls in the auto industry, or mandatory technical orders or airworthiness directives that result in increased safety of aircraft. As in those industries, we cannot practically anticipate all possible situations affecting our weapons, nor can we test for them. Informed and validated judgments by weapon scientists continue to be imperative, and these can only be sustained by continuation of the most important part of the experimental part of the weapons program: nuclear testing. Most often, of course, we conclude that no nuclear test is necessary to resolve a problem. These are the most critical judgments of all.

We have been able to meet the military requirements of the past decade under the test-yield constraint of the Threshold Test Ban Treaty (TTBT), but only because the yield limit is high enough to allow us to exploit some components that had been tested at full yield prior to imposition of the TTBT limit. The necessity to use the older technology of those designs carries certain military and dollar penalties. Nevertheless, we are optimistic about our ability to meet military requirements in the future under the 150 kt limit, but this cannot be guaranteed. If the limit were significantly lower, our optimism would be extremely difficult to sustain.

To summarize the danger inherent in further test limitations, in addition to the inevitable loss of validated design judgment, let me point out the following:

> During the 1958 - 61 Moratorium on testing, we discovered serious safety problems that only could be resolved after testing resumed. In the interim, some of our deployed forces suffered severe operational restric-tions.
>
> After testing resumed, we discovered serious reliability problems with some of our nuclear weapons through testing. These problems could only be resolved through further nuclear tests. If testing had not resumed, we would not have known for sure about these problems, but our suspicions would have led in some cases to severe loss of confidence in the weapons involved. In other cases, the result could have been false confidence in weapons that probably would have failed in use, particularly if we had made incorrect decisions based on the inadequate knowledge of that period.
>
> Problems with nuclear weapons continue to be revealed and resolved by nuclear testing that can be solved in no other way. There has in fact been a new problem on the average of every two years since the Moratorium, some very recently. One third of the stockpile weapon designs introduced since the Moratorium period have required further testing after entry of the weapons into the U.S. forces, and in three fourths of these cases, discovery or confirmation of the problem was only possible because nuclear tests continued after the weapons were deployed. I should add here specifically that nuclear tests limited to 1 kiloton would have been entirely inadequate for this purpose.
>
> We cannot prove that there will be similar problems with our nuclear weapons in the future; we have only past experience as a guide. The Thiokol engineers were asked by senior management officials whether they could prove the Space Shuttle booster rocket would have a problem. They could not; they could only give their professional judgment, based on experience, that a problem was likely. Thus the decision was made to launch Challenger.

The President has stated the situation clearly:

> "The security of the United States and the entire free world, today and for the foreseeable future, depends on the maintenance of an effective and credible nuclear deterrent by the U.S.
>
> . . . a comprehensive test ban is a long-term objective which must be viewed in the context of a time when we do not need to depend on nuclear deterrence to insure international security and stability . . ."

I hope that I have been able to explain some of the technical reasoning that supports the President's judgment on this matter. We have been able to do our job so far under the TTBT limits, and support the Administration's initiative for ratification with adequate verification, but I strongly urge that further constraints on nuclear testing not be considered until genuine progress in the arms control process makes such actions less dangerous to U.S. national security than I believe they would be at present.

X RAY LASER R&D

Senator JOHNSTON. Now, Dr. Batzel, tell us about the x ray laser tests, what you have proved, and how far you have to go in that program.

Dr. BATZEL. Could I ask Dr. Miller, who is in charge of that particular area, to respond? I can speak to that, but he can elaborate on that better than I can.

Senator JOHNSTON. Yes.

Dr. Miller?

Dr. MILLER. Thank you very much.

We have conducted, to date, [deleted] tests of the x ray laser. In those tests, we have clearly shown the existence of the x ray laser. [Deleted.]

Senator JOHNSTON. When I was last out at Livermore, you proved the principle of lasing, and [deleted].

Dr. MILLER. [Deleted.]

Senator JOHNSTON. Now, fluency is what?

Dr. MILLER. That is a physicist's jargon for how much energy you get to a target.

Senator JOHNSTON. Have you solved that problem now, or is that a fundamental problem?

Dr. MILLER. [Deleted.]

Senator JOHNSTON. [Deleted.]

Dr. MILLER. Nothing in physics is ever straightforward. [Laughter.] [Deleted.]

Senator JOHNSTON. What kind of power test, how many kt's do you foresee on present tests and over the next 5 years?

Dr. MILLER. [Deleted.]

Senator JOHNSTON. If your testing were successful and you were able to build a prototype and all of your proof of principle went out straight-forwardly [deleted] how many kt's as a weapon would you foresee, and how many separately targetable beams would you envision could come from that weapon—from that explosion, excuse me?

Dr. MILLER. [Deleted.]

Senator JOHNSTON. [Deleted.]

Dr. MILLER. In terms of the relative problems that SDI has to face in pointing and tracking, this is a very straight-forward problem.

Senator JOHNSTON. Where do you see the Soviets at this? [Deleted.]

Dr. MILLER. Yes, sir.

If we look at the Soviet program, we have lots of unknowns. What we do know is that the original idea for the x ray laser came from the Soviets. The physics of the particular laser that we are working with was published by the Soviets in 1973, and they have had sufficient opportunities to have engaged in a vigorous development program.

[Deleted.]

Senator JOHNSTON. Now, all of this [deleted] program would be underground tests, then?

Dr. MILLER. Yes, sir.

We do not need to test the x ray laser either during the development or, should we ever choose to deploy, we would never need to do a test in the atmosphere. We could do everything we need underground.

Senator JOHNSTON. You could do everything underground?

Dr. MILLER. Yes, sir.

Dr. BATZEL. Yes.

Senator JOHNSTON. That is amazing.

I would expect the software would probably be the more difficult thing to do on the development than almost the x ray laser.

[Deleted.]

Dr. MILLER. We did a study several years ago with Martin Marietta, trying to look at what the elements of a system are that would use an x ray laser. We believed at that time, and I still believe, that the most difficult technical problem is [deleted].

Senator JOHNSTON. And you feel like you are well along with a solution to that problem?

You already have proof of lasing [deleted].

Dr. MILLER. The way I would choose to say it is that we are well into the research program. We remain very optimistic about the outcome of the research program. But it is still a research program that could lead to surprises.

Senator JOHNSTON. [Deleted.]

Dr. MILLER. [Deleted.]

IMPACT OF TEST BAN

Senator JOHNSTON. Thank you very much, Dr. Miller.

Getting back to the question of symmetry, we have discussed the question of robustness, that the Soviet program would need less testing than ours because they are more robust, with greater throw-weight, and we have greater safety requirements.

But let's say that we put an absolute ban on further nuclear tests of any kind. Are there arguments, other than robustness and safety—for example, a greater need on the part of the United States to deploy new weapons than on their part—and that begs the question of whether we have tested enough to go ahead and deploy MX and D-5 without further testing. I know it would be good to do so.

Would you speak to that issue?

Dr. BIRELY. I would like to speak to that issue. Look at the Soviet modernization program. They are several generations further down the road on their strategic missiles.

They are already deploying, for instance, a road mobile system, and are close to deploying rail mobile. We are still talking about those basing modes for MX and for Midgetman. But we do not have the warhead for Midgetman.

Senator JOHNSTON. Well, we would not have to have a separate nuclear test for a rail mobile MX, would we?

Dr. BIRELY. No, sir; but we would have to undergo a testing and development program for the Midgetman.

The point I am trying to make is that the strategic modernization program that the Soviets underwent is substantially further along than ours, and were you to quench that now in terms of the warheads, I believe that we would be at a substantial disadvantage.

Senator JOHNSTON. Because of Midgetman?

Dr. BIRELY. Because of Midgetman and because, when you look at the emerging Soviet target base, the two hardest things for us to cope with right now are their mobile targets and their extremely deeply buried and extremely hardened targets.

[Deleted.]

Dr. BIRELY. There is a plan on how to get somewhere, and that would involve, in the near term, using some of our higher yield bombs. But, in the long run, we are looking at a technology called Earth penetration.

EARTH PENETRATOR WEAPON TECHNOLOGY

Senator JOHNSTON. That was going to be my next question.

Dr. BIRELY. This is where one would burrow into the earth with a warhead. It turns out that if you explode a warhead on the surface versus putting it into the earth, [deleted] more effective.

Senator JOHNSTON. For underground targets?

Dr. BIRELY. Yes; for underground targets.

[Deleted.]

Dr. BIRELY. Both laboratories are working vigorously on this, now. But, again, if testing stopped, we would have to give that option up as well.

So, if testing stopped today, there would be an enormous asymmetry in terms of which of our targets they could hold at risk and which of theirs we could hold at risk.

Senator JOHNSTON. And now the critical path on the penetrator, is that on designing the case that will go into the ground, or is that on making the nuclear explosion?

Dr. BIRELY. It is on both of those because the case has enormous mechanical deceleration as it goes through there, [deleted]..

Senator JOHNSTON. How do you test that?

Dr. BIRELY. We do two things in parallel. We design the nuclear weapon and make sure it works without those stresses. Then we put the nuclear device, minus, of course, the plutonium, and indeed today minus the high explosive, into the penetrator and shoot it with a gun into rock of [deleted].

So there is a nonnuclear testing program to test the mechanical integrity and a nuclear testing program to make sure that the system with the configuration necessary to fit into this penetrator actually works as designed.

Senator JOHNSTON. Dr. Batzel, did you want to speak to that?

IMPACT OF TEST LIMITATION ON SCIENTIFIC MANPOWER

Dr. BATZEL. Another asymmetry which I am sure will occur is the fact that the United States will rapidly lose its most precious resource; namely, the nuclear designers.

From 1958 to 1961 we went through that. You always lose your best people, because they do not want to work on something which is not going to be important. They are going to take on other jobs. They are the most easily placed people, the most sought after.

[Deleted.] I do not delude myself into thinking that the Soviets are not going to instruct those people to stay there and work their problems. I think they will.

If I were trying to put the United States at a disadvantage, the best thing that I could think of from the Soviets' point of view would be to have a moratorium for 5 years and resume. I know where the United States will be, and I am afraid that I know where the Soviet Union will be.

SOVIET TEST VENTING

Senator JOHNSTON. I really am taking too much time, but let me ask one more quick question.

Admiral, you said that in one of the Soviet tests there was radioactive gas detected outside the Soviet borders, which you thought was a violation of LTBT.

Admiral FOLEY. Yes.

Senator JOHNSTON. How did that happen? I mean, why does the gas escape?

Admiral FOLEY. Roger?

Dr. BATZEL. [Deleted.]

Senator JOHNSTON. [Deleted.]

Dr. BATZEL. [Deleted.]

Dr. BARKER. I think primarily, though, it just shows their callousness of the whole problem.

Admiral FOLEY. [Deleted.]

Dr. BIRELY. [Deleted.]

So, it is something that we are scrupulously careful about.

Senator JOHNSTON. Senator Stennis, do you have any questions?

Senator STENNIS. No; but I am very glad that I got to hear this. It is highly valuable to many of us, I know.

Senator JOHNSTON. Well, these are laboratories for which I have the very highest regard.

Senator STENNIS. Yes; I do, too.

Senator JOHNSTON. I think they have absolute credibility, as far as I am concerned.

Senator STENNIS. I know their credibility and I very much appreciate what they do.

Senator JOHNSTON. Thank you, Senator Stennis.

Senator Hatfield.

CORRTEX VERIFICATION TECHNOLOGY

Senator HATFIELD. Thank you, Mr. Chairman.

Admiral Foley, could I get back to the CORRTEX issue.

As you know, this has been a topic of debate for quite some time.

I do not want to debate the merits or get into the merits of the system with you, but as I understand it, there were some invitations extended to people at Livermore and Los Alamos to attend a technical workshop in Moscow, and that the invitations were not accepted.

I understand now that Mr. Velikov, a vice chairman of the Soviet Academy of Sciences, has issued a sort of open-ended invitation.

My question is this. Has the Department taken a position on those invitations? If so, what is that position?

Admiral FOLEY. Sir, let me give you a little historical background there.

I received a phone call—I think you called me, Roger—to indicate that he had received a telephone call from Velikov extending the invitation to send people over and my response was for the Department to say "No."

I said "No" because we already had a venue in which Dr. Barker was leading the team and made the offer to the Soviets to come and observe, to get all the information about CORRTEX. And, as I told Dr. Batzel, the proper venue for discussion on CORRTEX is that of Dr. Barker and the Soviet Union in an official capacity. And we would provide whatever additional information was required in that venue.

NUCLEAR TEST EXPERTS MEETING

Dr. BARKER. I can add a little more information, Senator.

I have headed up the nuclear test experts meetings with the Soviet Union for four sessions now, beginning in July of last year.

I have very heavily involved the experts from both Los Alamos and Livermore, the CORRTEX experts, and seismic experts, as part of my negotiating team in dealing with the Soviets.

We had meetings in July and September. At the July meeting, the only technical discussion was on CORRTEX. The two experts from Los Alamos made technical presentations, and the entirety of the technical question and answer period was the Soviet experts asking those two individuals questions for technical amplification about the capabilities of CORRTEX.

During those presentations, we made the offer of providing a set of CORRTEX instrumentation to the Soviets, so that they could use the instrumentation by themselves on their own tests to confirm that what we were saying about it was true.

We invited them to come to Nevada to see us implement the CORRTEX instrumentation so that they could see exactly how we used it to make the kind of measurements we were talking about.

In September, I had the Deputy Director of the Nevada Operations Office come to Geneva with me. He is the one who would be responsible for hosting the Soviet delegation, were they to come to the U.S. test site as part of implementing the CORRTEX technique.

He went through the entire procedure from the day they arrived—how they would be housed, how they would be fed, what kind of measurements they would be permitted to make, et cetera.

In November, the third session started. [Deleted.] We have agreed to do that.

So I have just returned, last Saturday, from the fourth of these sessions. The session began in January and broke for a short period, and resumed again this month. In 18 working days, we spent 20 head-to-head sessions trying to come to an agreement on an acceptable agenda.

The Soviets, in the meantime, have tried this parallel technique of short-circuiting a government-to-government process by claiming that they are operating on a private basis. The Soviet Academy has been dealing with the NRDC, as you know, with respect to the installation of seismic stations in the Soviet Union and the United States.

They started to bring up this CORRTEX issue in, I believe, January of this year. Is that when the calls first started coming?

Admiral FOLEY. Yes.

Dr. BATZEL. Yes.

Dr. BARKER. Despite the fact that they keep talking about this as a private organization outside of government channels, it is interesting that this meeting in February——

Senator HATFIELD. Excuse me, but where did these messages come from and to whom?

Dr. BARKER. Directly from Velikov to individuals at the laboratories; I think to Roger, as Director of the laboratory.

Dr. BIRELY. And to Sieg Hecker as well.

Dr. BARKER. The meeting in February, to which they were first invited—there were two experts from the Soviet delegation at that meeting. I think that puts aside all pretense that this is some kind of private group to private group activity on the part of the Soviet Government. It is a very conscious activity, with Velikov as the ringleader, of avoiding the process of dealing on a government-to-government basis.

We have established no barriers whatsoever to discussion of CORRTEX technology through our discussion forum. In fact, I repeatedly reinvite them to see the instruments in use in Nevada. I continually offer them use of the instruments themselves. I continue to offer a separate technical forum in Geneva at which experts can talk to each other, while our other discussions on agenda go on. [Deleted.]

Admiral FOLEY. In addition, we have said at Nevada that we will make it very open. We will let the press, both United States and Soviet, in on whatever determinations were made by the government. We have been very, very open for the whole process, beyond what we do right now.

Dr. BARKER. I do not know all the U.S. experts who have been contacted. But I know that three of the four scientists whom I had on my delegation were separately contacted by Velikov. They called me up to tell me that they had declined the invitation and told Velikov that they were quite prepared to pursue technical discussions in Geneva as part of a government-to-government process.

Senator HATFIELD. According to my information, Dr. James Hannon and DeWitt Hecker and Kidder at Lawrence Livermore were asked, and the same telex was sent to Bob Jeffries and Don Westervelt.

Dr. BARKER. Mr. Westervelt is right here.

Senator HATFIELD. Would you care to speculate a little bit as to what the basic objective is on the parallel strategy that seems to be followed now by the Soviets?

Admiral FOLEY. Well, there is speculation, and in my personal judgment, it is simply a public relations ploy.

Senator HATFIELD. What would they gain in public relations if you have made this very open kind of offer to them?

Admiral FOLEY. I don't know. But I see nothing to our advantage to going over and doing that, when we have been as open as possible in government to government.

I would much prefer some response in that venue before taking on some short circuit or parallel path, where I have no idea what the objective is.

Senator HATFIELD. I am not urging you to go there. I am just trying to think in my own mind what their advantage is. It seems to me they are at a disadvantage. They are in a defensive role, where you have been so open and they have not responded.

Dr. BARKER. Well, I have been open in a private diplomatic channel. As far as the public domain is concerned, I am not sure what information you had about this previously, but you may have been led to believe that the only avenue of willingness to discuss was the Velikov initiative, which the U.S. scientists had been persuaded to turn down. It can be portrayed that way and would certainly put the United States in the negative, whereas nothing would be further from the truth.

It is we who took the initiative in private diplomatic channels to initiate this.

Admiral FOLEY. Also, Bob, the full orchestration of what was taking place over there would be controlled by the Soviets and whatever light, whatever flavor, or talking they would want to do would be controlled by them and not by us, nor even an even-steven balance.

Senator HATFIELD. I would not engage in anything on that basis.

Admiral FOLEY. Neither would I, sir.

Dr. BIRELY. Well, there is another related thing, of course, that we did not enter into. The NRDC sent people over for conventional seismic monitoring techniques in the Soviet Union. When it came time to actually have a nuclear explosion, they were told to turn off the equipment. So the one opportunity that they really had to do something of a technical nature related to arms control was suppressed.

Senator HATFIELD. Well, there is no question that you have to lay every detail out in a preagreement before you engage in anything there. I understand that. I just was not aware of your private diplomatic efforts, Dr. Barker.

Let me ask you this. Is this a classified hearing—not the hearing in general, but the information that you have given me regarding the private diplomatic initiatives and invitations; is that classified?

Dr. BARKER. I think you should feel free to use that, Senator, the fact that we have offered them equipment, the fact that we have offered them the opportunity, the fact that the President openly made the invitation to have them come to Nevada and see the instrumentation.

I think the only thing that I probably have not said in the public domain myself is to make the point that [deleted].

I agree with them that the primary emphasis should be on trying to establish an agenda that would permit true negotiations in substance to happen. [Deleted.]

But our open willingness to discuss these issues with them technically is something that should be public, that should be made known.

Senator HATFIELD. Again, do you think it is purely on the basis of the matter of turf on which these discussions should take place?

It seems to me they would want to seize that opportunity that you have offered them, to come and see this all first-hand.

NEGOTIATIONS WITH THE SOVIETS

Dr. BARKER. Officially, I think they do not want to do that until we have agreed on an agenda. So they are using Geneva as a negotiating tool.

Senator HATFIELD. But I am not clear enough in my own mind, I am not enough of a student of this, to see what would be in the agenda that would be so paramount that they would not grab an opportunity to get on the scene?

Dr. BARKER. As you know, just before Reykjavik last year, the President agreed with the Congress to change what had, up to that point, been the administration's public position on nuclear testing and arms control. He said at that time that as soon as the TTBT verification improvements are negotiated and ratified, we would really begin discussions and negotiations on further limitations, provided that reductions in arms control and nuclear weapons justified such agreements.

The Soviet's position on Geneva [deleted].

Admiral FOLEY. Let me give you another theory.

Dr. BARKER. Of course, that is a guess.

I have long ago learned that I could not possibly predict the reasons for Soviet behavior on the basis of my limited experience.

Admiral FOLEY. Let me add to that.

I headed up two negotiating teams with the Soviet Union in my Navy days, when we had one in Moscow and one in the United States, to prevent incidents at sea.

When they came to the United States, they came to San Francisco on an excursion, and I invited them to the U.S.S. *Enterprise*, a nuclear-powered aircraft carrier. We knew they were building one. I invited them aboard for luncheon and a tour. They declined.

Now, you might ask why would they decline, why wouldn't they leap at this opportunity? Because of quid pro quo.

They knew that when we went to the Soviet Union the next time, I would want to have a quid pro quo with one of their ships and they did not want to do that.

So, it may be the same sort of thing. We would want to see their test site and clearly be resident on over there and find out things, and they have a paranoia about that.

Senator HATFIELD. You know, you might compare notes with William Campbell out at Hoover, because they have always wanted access to those magnificent Russian archives, and, you know, if we can get access to their archives—something like that kind of arrangement. [Laughter.]

They have been very good on that kind of arrangement for quite some time.

Thank you, Mr. Chairman. I appreciate your courtesy.

Senator JOHNSTON. Thank you.

Senator McClure.

Senator McCLURE. Thank you, Mr. Chairman.

I hope you did not go into this while I was gone, but I had to go and meet with a group of people from the Northwest for a few minutes, who got a lot of propaganda on behalf of Senator Hatfield while I was there, saying what a great Senator he is, and, of course, I cheered. [Laughter.]

Senator HATFIELD. The guys are quoting me. That is dangerous. [Laughter.]

SOVIET TEST MORATORIUM

Senator McCLURE. I want to explore for a moment what kind of looks like a casual aside in Admiral Foley's statement. While I don't think it was just a casual aside, it was not the point of the testimony. It is this. [Deleted.]

Admiral FOLEY. [Deleted.]

Senator McCLURE. [Deleted.]

It can be argued that, well, maybe if we had joined with them, they would not have conducted those tests and they would have wasted all of that preparation.

Well, I will not hold my breath. Maybe we will see whether or not that is true.

Second, I want to test just a little bit this question of what is real verification.

VERIFICATION TECHNOLOGY

I have heard some discussion, but how do you really verify what happens down a hole unless you have a calibration test?

Doesn't that mean that you have to put one of your own known yield weapons down that hole and fire it?

Dr. BATZEL. If you want a calibration test, you had better know what that yield is. The only way you are going to know what it is is probably to furnish your own.

Dr. BARKER. Let me backtrack just a little bit.

CORRTEX is a technique that has been used in the United States, in fact by Los Alamos Laboratory, I don't know how many times, to measure the yield of our own U.S. tests.

Dr. BIRELY. It is routinely used down the main hole and it has been used with increasing frequency on satellites also.

Senator MCCLURE. Do you believe there is any prospect at all that the Soviets would ever allow us to go over and drop one down their hole?

Dr. BARKER. Drop a U.S. device?

Senator MCCLURE. Yes.

Dr. BARKER. No; I don't.

So, what we will have done is we will have calibrated the CORRTEX technique against U.S. bombs on U.S. soil, and the physicists tell us that they understand the soil well enough to know that the same physics holds in the Soviet Union that holds in the United States.

Senator MCCLURE. If you know enough about the soil down in the hole.

Dr. BARKER. That is correct.

Senator MCCLURE. And if you know enough about the yield down in the hole.

Dr. BARKER. Maybe I could tell us a little bit about the procedure that I have proposed to the Soviets.

As I said, I had a deputy manager from the Nevada Test Site come out and explain the procedure. We have postulated that, used as a verification technique, the measuring side, let's call it, the Soviets at our test site or vice versa, would be present to watch the drilling of the satellite hole in which the CORRTEX cable would be placed so that the measuring side would have total access to all of the geological samples coming up as the hole was drilled.

The measuring side would be able to lower television cameras, gamma logs, instruments that would enable one to test the integrity of the side of the hole, and make sure there were not hidden cavities or hidden chambers behind the walls. The measuring side would have the ability to monitor the lowering of the device down the device hole.

So, all the things would be shrouded so that there would be no details available to the measuring side, but you would indeed be guaranteed that the device went down to the bottom and did not stop someplace short of the bottom, to provide some method of spoofing the instrumentation. The measuring side would be present while the CORRTEX cable was lowered into its hole and be present during the whole time it was backfilled to make sure that everything was filled properly.

We have gone through this. We have gamed it. We have asked how could someone who desired to fool this system could go about fooling it. In fact, I think we have trained the Russians well enough that they have come up in the discussions we have had with some spoofing scenarios themselves.

How could they be sure that we have not done these things to them, you know.

So it has truly turned into a dialogue, [deleted] of how can you indeed insure 30-percent accuracy with this instrument when used as a verification tool.

It is important to know that when Los Alamos uses it to diagnose their own devices, when they know everything about the device, everything about the geology and they put the cable down the same hole, they have been able to get [deleted].

So we have doubled the inaccuracy, if you want, of the technique, associating it with, or using it as a verification tool.

Senator McClure. Well, it seems to me that there are two traps. One is, can you fool us in the details you are talking about. Second, I don't think you can really calibrate. I am not yet convinced that you can really calibrate unless you have an instrument of known yield.

Dr. Batzel. I think, in fact, that one can make a measurement on that device if, indeed, you can constrain the environment very carefully and make sure you have the measuring instruments there unimpeded. Then I think you can measure that yield to 30 percent.

Senator McClure. The second trap that I see is what we set up for ourselves under a treaty verification and compliance regime is "prove it in court."

Dr. Barker. That is a political problem; that is not a technical problem.

Senator McClure. But that is a problem.

Dr. Barker. Yes; you are exactly right, it is a problem.

Senator McClure. I don't know if there are any variables and uncertainties, that we really have anything more to go on than we have now in terms of the political reactions to it.

Dr. Barker. I think you have hit upon one of the critical challenges to arms control that exists. Verification can never be perfect. There will always be some uncertainty associated with it. The political authorities—the administration as well as the legislative branch—had better be ready to recognize that they are going to have to call a violation on something less than perfect proof. Unless they are willing to do that, we are going to let violation after violation go by unchallenged. We are going to create controversy and undermine arms control.

Senator McClure. And there will be two reactions to that. One is if you attempt to do it and there is uncertainty, there will be tremendous political criticism for your action because you really don't know.

The second point is the Russians will always say, "How do you know; prove to me that you know." Then you have to reveal to them exactly what you do know and what you don't know. In that process, they gain a great deal more knowledge than we do.

I am very skeptical about whether or not this system is accurate enough to remove those two pitfalls.

Dr. BARKER. Clearly, whether verification is good enough is ultimately a very subjective judgment, which must be made by the highest authority in the land.

The President asked the executive branch to do a study as soon as he came into office in 1981. After 1½ years of study, he did come to the conclusion that [deleted] which is the best we could do by seismic techniques, is so totally unacceptable that he would not consider ratifying those treaties or asking the Senate to give its advice and consent.

He asked the technical community, "What is the best you can do?" The Department of Energy came in with this technique, called CORRTEX, and convinced everybody who looked at it that they could indeed meet the 30-percent criteria. The President was then told that 30 percent is the best that we know how to do.

He then went on and made the judgment that it was his opinion that 30 percent was good enough; that if the Soviets were willing to accept the technique, he would be prepared to ask the Senate to provide their advice and consent to the treaty.

The Senate gets to decide for itself whether it is good enough for them, of course.

Admiral FOLEY. But there is a significant reason why the 30 percent is important—because the 30-percent error is probably not militarily significant.

In other words, if you can measure within 30 percent, you have a good feel for what the military capability of that burst might have been.

It is probably acceptable to you on that.

Dr. BARKER. I think that has to be one of the factors that was considered.

Admiral FOLEY. Yes; it was one of the factors of consideration.

Now double, that is a different story, if you are off by a factor of two. But 30 percent is probably livable, and that I think is why it was accepted.

Senator MCCLURE. Well, there is another thing outside of the purview of this hearing. As you indicated, it is really up to the Senate to make a decision. That is, do you have the national will to do anything about a Soviet violation.

I am satisfied that they have been violating it all along.

As I look at the test data and the yields, every time we change the criteria to reduce the uncertainty, they have upped the yields.

Now, that does not inspire confidence in me that they are going to try to find ways to do that, and every time they have done that, we have found another reason to excuse them.

Dr. BARKER. [Deleted.]

Senator MCCLURE. Well, I just look at the data and the way they plot on a chart.

Dr. BARKER. It is very, very disturbing, and it is one of the factors that led the President to conclude there were likely violations.

[Deleted.]

Admiral FOLEY. But the fundamental issue is one of arms control and reducing weapons. If this verification gives us sufficient confidence that you can then move forward and make reductions, then it is a major step forward. In my judgment, at least, and in that of the Department, it is worth accepting the risk of verification as a means for moving forward.

But, ceasing testing or further limitations on testing, without confidence-building verification, is assinine, in my personal judgment.

Senator MCCLURE. There is a strong letter to follow. [Laughter.]

Admiral FOLEY. I think they are messing around with national security. It is politics rather than national security. I have a fundamental objection to imposing a 1-kt limit, for example, when, from a military viewpoint and national security viewpoint, all the arguments flow in the other direction. To have a group come up with that as national policy I find abhorrent.

Senator MCCLURE. Thank you.

STRATEGIC DEFENSE INITIATIVE (SDI)

Senator JOHNSTON. Thank you, Senator McClure.

Gentlemen, this whole issue of testing, as we saw with the x ray laser, is very well connected to the SDI program. I have talked to some of you at various times about SDI and the kinetic kill portion of SDI.

While in one sense it is not connected with nuclear testing because it is a nonnuclear program, on the other hand, it does relate to the whole program which, in turn, is related to testing.

My question, I guess, is for Dr. Batzel or Dr. Miller.

It is my information that fast-burn technology for rockets is today's technology for both us and the Soviet Union, and that a kinetic kill system, and I guess that means rockets at this time, would fail catastrophically against a fast-burn system of the Soviet Union; is that correct?

Dr. BATZEL. I think Dr. Miller is going to speak to that issue specifically tomorrow.

Clearly, the fast-burn booster complicates the hell out of things with respect to boost phase defense.

Details of that depend on the maximum velocity of what your kinetic kill vehicle can be and the actual fast-burn time.

How it fails is not clear to me at this stage of the game. You know, it could fail catastrophically or it might fail not so dramatically, perhaps gracefully. I don't know.

Dr. MILLER. I guess I would say that [deleted] a fast-burn booster, which burns out in 80 seconds at 100 kilometers, the kinematics are such that the space-based KKV cannot get it. You then have to ask, how does the whole system fail. What fraction of the total system relies upon the boost phase and that clearly kinematically such a fast-burn booster would negate totally that portion of the system.

It is also possible to get the limit down so that the post-boost phase is also affected. Those two early phases—boost and post-boost phase—are affected severely by the fast-burn booster.

Senator JOHNSTON. I know that we are going to go into this in more detail another time, but for the personnel who are here today—which would be different from the Defense Appropriations Subcommittee, at least in part—I would ask this: If you were the decisionmaker on the question of the deployment of a kinetic vehicle system—in other words, you were making decisions on which way to go on choice of technology—what would you say to the kinetic kill vehicle deployment system?

Dr. MILLER. I think that, at this time, we do not have the full range of technology explored to the point where any deployment system, any deployment decision, is appropriate.

Before you begin deploying it, you must understand both where the near-term options and the long-term options will ultimately lead you, and we do not have that full range of technical information in hand today.

Senator JOHNSTON. So you are saying that kinetic kill vehicles are, in fact, a real possibility, that we ought to look into them, and that it makes sense?

Dr. MILLER. I think that it is appropriate to continue research and development of the idea of a KKV to find out if you can get the velocity [deleted]. It might make some difference.

But any deployment system, any deployment decision has to wait until we have a complete set of technical options explored.

Senator JOHNSTON. What does that mean?

Admiral FOLEY. We don't know yet.

Dr. MILLER. It means to me that the fast-burn booster, for instance, can affect the space-based KKV in a very negative fashion. If you decide that you want to use the space-based KKV as a mechanism to force the Soviets away from the SS–18's, that would be a military objective. I will not comment on whether that is a good objective or a bad one. But the space-based KKV can attack the SS–18's with no problem.

If you want to use the space-based KKV's to force the Soviets to go away from the SS–18's, you had better have in place the follow-on system that will attack the fast-burn booster, or else you will have proceeded down a path that will get you into trouble.

Senator MCCLURE. May I ask a question in that regard?

Admiral FOLEY. That is a very important point.

Senator MCCLURE. Is there an economic tradeoff here, in which it costs us less to threaten their current boosters than it costs them to replace them?

Dr. MILLER. Whether there is an economic tradeoff in the right direction, I don't know. You certainly must ask the question.

Senator MCCLURE. The reason I ask that is this. Before a fast-burn booster defeats kinetic kill capability, they have to replace all their current boosters.

Dr. BATZEL. It certainly costs them significantly to counteract kinetic kill vehicles.

Senator McClure. It would cost them to build a new inventory.

Dr. Batzel. That's right.

A tradeoff has to be made. You have to sort that out and see where all of it comes out.

Senator Johnston. I just cannot conceive under any circumstances of—I mean, to me it is absurd—please excuse me if I am too strong—to say that you could build a whole kinetic kill vehicle orbiting in the sky, controlled by all of this software that has never been designed before and do that at a cost at which all the Soviets have to do is to put on fast-burn boosters.

Now, really, you are not telling me that? I have been told differently from that by people at your labs.

Dr. Birely. I would like to come back to a couple of earlier points.

I am not persuaded that the fast-burn booster is just a simple extrapolation of today's technology. But I certainly think, looking at the past engineering development costs for major strategic missile systems and the costs of buying them, that this would be an extremely expensive investment.

Even if you made that investment, however, the fast-burn booster has appeared at times, between the time it stops burning and the time it deploys the RV's—because it stops burning in the atmosphere. It cannot just pop the RV's out at that point and get them going.

So you still have basically the same amount of time to attack that system that you do the current missile systems. It is just that the sensing problems are more difficult because you are not sensing a missile plume. You are looking with passive sensors.

But I believe we have discussed this with members of your staff and Senator Proxmire's staff when they visited Los Alamos. Certainly during those discussions at which I was present there was not unanimity that fast-burn booster technology was here today.

There seemed to be quite an agreement that it would be very expensive to implement.

Senator Johnston. What order of magnitude of cost are we talking about?

Dr. Birely. I don't know the engineering and development costs offhand.

Senator Johnston. [Deleted.]

Dr. Miller. [Deleted.]

Dr. Birely. Yes.

Dr. Miller. We have designed a fast-deployment system that will deploy in 30 seconds instead of 700 seconds.

So I guess I would disagree that there is unanimity that design of a fast-burn booster is a hard job. There is not unanimity that it is a hard job.

Dr. Birely. There is not unanimity that it is an easy job, either.

Senator Johnston. Would you say that we have essentially done it?

Dr. Miller. We have not physically done it. We have designed it, and the engineering looks straightforward.

Senator JOHNSTON. [Deleted.]

We are talking magnitude here. What kind of magnitude are we talking about? What are their priorities?

Dr. BATZEL. Let's see—there are 300-some missiles, right—SS–18's.

Dr. BARKER. Only the 18's, or the whole force?

Dr. BATZEL. Well, we were talking about the 18's.

Senator JOHNSTON. Pick whatever missiles you want.

Dr. BATZEL. You asked what it would cost to turn that into a fast-burn booster?

Senator JOHNSTON. Yes; a fast-burn force.

Dr. BATZEL. I would have to go and take a look at that.

Dr. MILLER. What you know is that the total MX development was like $30 billion. The small ICBM with the total mobile system is expected to be in the $60 billion range.

Dr. BATZEL. And that is for 500 SICBM's, small ICBM's.

Dr. MILLER. That gives you an order of magnitude for what the complete development costs of a major U.S. strategic missile system is.

Senator JOHNSTON. Well, a good bit of that was warheads as well.

Dr. MILLER. The warhead is insignificant.

Admiral FOLEY. It is about 10 percent.

Dr. BATZEL. It is not a major part of that.

Senator JOHNSTON. All right.

Do you know about how far along the Soviet Union is with the x ray laser? [Deleted.]

Dr. MILLER. [Deleted] that that is what it is.

Senator JOHNSTON. Well, we really do not think they would be [deleted] do we?

Dr. BATZEL. Well, we feel we could complete our testing underground, you know, and check the fundamentals of the system underground, without an atmospheric test. [Deleted.]

Dr. BIRELY. I would like to point out that, in addition to x ray lasers, there are a number of other nuclear-driven concepts that are being vigorously investigated in the United States.

Senator JOHNSTON. Some of those are in this budget as well.

Dr. BIRELY. That's correct.

Senator JOHNSTON. Would you explain those?

KINETIC ENERGY WEAPONS

Dr. BIRELY. Well, yes. The one that we are pursuing most vigorously at Los Alamos is what you might call a [deleted].

When you look into the Soviet literature, this technique was applied many, many years ago to do fundamental studies of the properties of matter.

A second approach that we are looking at is trying to convert——

Senator JOHNSTON. First, tell me how that would work.

Dr. BIRELY. OK.

Senator JOHNSTON. Would you have one explosion a wide area?

Dr. BIRELY. [Deleted.]

Senator JOHNSTON. [Deleted.]

Dr. BIRELY. [Deleted.]

So, I think what George said and what I have said is that the tracks are there in the literature for having been very active before we were, and in areas where their technology is strong and historically well funded.

NUCLEAR TEST PLANS

Senator JOHNSTON. Can you tell me the number of tests for next year in this budget, the costs of those tests, and the number that are for SDI and the number that are for new weapons and the number that are for reliability?

First of all, the number of tests.

Mr. CULPEPPER. The number of tests we plan right now, sir, depending on the final budget, is [deleted].

Senator JOHNSTON. Compared to fiscal year 1987?

Mr. CULPEPPER. We expect about the same number.

Senator JOHNSTON. OK. The costs?

Mr. CULPEPPER. The total cost for testing the program is about $690 million. That is what we are expecting in 1988.

Senator JOHNSTON. The number of those for SDI?

Mr. CULPEPPER. In 1988, we expect [deleted] SDI tests.

Senator JOHNSTON. And those are how many x rays?

Mr. CULPEPPER. Right now, we are planning [deleted].

Senator JOHNSTON. OK.

And the others for reliability and new weapons?

Mr. CULPEPPER. We probably have several that would be weaponization, including [deleted].

Senator JOHNSTON. [Deleted] altogether?

Dr. BARKER. Let's get the categories straight.

Reliability and confidence is likely to be [deleted].

Admiral FOLEY. Are we off the SDI now?

Senator JOHNSTON. Yes.

Mr. CULPEPPER. We would have a total of weaponization planned to be [deleted].

Senator JOHNSTON. That is new weapons?

Mr. CULPEPPER. [Deleted.]

Senator JOHNSTON. And then?

Mr. CULPEPPER. For advanced development, we plan [deleted].

Senator JOHNSTON. And those are what?

Mr. CULPEPPER. Various kinds.

Senator JOHNSTON. [Deleted.]

Mr. CULPEPPER. Some of the work could include that; yes, sir.

Senator JOHNSTON. You say "could." Has it been planned?

Mr. CULPEPPER. It will be. But I just say that I cannot categorize it or categorically tell you.

Dr. BATZEL. There are some nuclear tests related to that.

Dr. BIRELY. As an aside, it is easy to categorize the tests, but, in point of fact, each one is complex and has more than one purpose. [Deleted.]

Senator JOHNSTON. How far in advance do you plan the actual tests?

Mr. CULPEPPER. Two years and eight months. But right now, we are going through the process of reviewing the program for fiscal year 1988, the interagency reviews, and then going up to the President for approval. We get that approval sometime in September or October, depending upon what you fund us for.

Then, most likely we have to reduce tests.

Senator JOHNSTON. So, the essential tests are planned, but can be modified based on what the President approves, what you have money for, and that sort of thing, what there is need for?

Mr. CULPEPPER. And any technological things that happen in the process.

We have had things this year that have caused us to adjust tests.

Admiral FOLEY. [Deleted] and how we get on with what we think would be the fundamental testing requirements before somebody stops us from testing. We believe if we can manage the tests or add things on, we should while we can.

NUCLEAR WASTE FUND

Senator JOHNSTON. Let me ask one related question before I get back to my colleagues. I know that Senator McClure will be interested in this.

We just put in a bill today to compensate whoever gets the nuclear waste area, we are going to give them for a repository, if the bill passes, $100 million a year for as long as they are using that repository out of the nuclear waste fund. [Laughter.]

You see, what we do with that is we save the characterization costs on two separate repositories, which are a billion dollars apiece, so we can pay for it out of that. As we pointed out, this is not to compensate for damage or problems or degradation of the area, but for the political problems that it causes. [Laughter.]

Dr. BARKER. It's actually a little sad.

Senator JOHNSTON. In any event, I am just wondering how many of these cavities you have [laughter] that are already in existence out there, how many polluted or contaminated test holes do you have in Nevada or out there?

Mr. CULPEPPER. About 600, I would say, 550 to 600.

Senator JOHNSTON. Is that classified?

Mr. CULPEPPER. No, sir.

Senator JOHNSTON. Are those radioactive forever?

Dr. BATZEL. Most of them contain plutonium, which has a half-life of 24,000 years, which is a long time.

Admiral FOLEY. Now, don't get yourselves into trouble with the politicians of Nevada. [Laughter.]

Senator JOHNSTON. Well, now, Dr. Batzel does not have to run in Nevada and neither do I.

What kind of area would this contaminate?

Dr. HOPKINS. Sir, I wonder if the impression was given that those are cavities.They are not 600 standing cavities. There are only a very few.

Senator JOHNSTON. Well, I mean areas. They were cavities for at least a microsecond.

Dr. HOPKINS. Yes; but it is not something that you can put radioactive waste into today.

Senator JOHNSTON. Oh, I know that; yes.

Dr. BIRELY. The depressions that you see on the surface are not contaminated. The contamination is down below and contained.

Senator JOHNSTON. And so it would be with the repository.

Dr. BATZEL. We monitor and have monitored the ground water contamination at the test site. We spent a lot of effort to make sure that we know what is happening to that radioactivity as a function of time.

So, the water movement is very slow and the actual movement of the contamination away from those sites is very slow.

Senator JOHNSTON. What kind of physical area would this cover?

Mr. CULPEPPER. Several square miles.

Dr. HOPKINS. The testing area is 1,350 square miles. The total area that is enclosed by the Nevada Test Site is that much. It may be 10 percent of that which actually would be used for nuclear testing. So maybe 130 square miles.

Admiral FOLEY. But that is a ballpark estimate.

Dr. HOPKINS. Yes.

Senator JOHNSTON. Well, this is very useful. I got a letter from somebody who said stop the nuclear waste and was telling me about the beauties of Nevada, because I had made a remark at a hearing that this was not a national park, for godsake, it was a nuclear test site. That offended him very greatly. So now I am armed.

Admiral FOLEY. It is more like the side of the Moon.

Senator JOHNSTON. Senator Stennis, did you have any further questions?

Chairman STENNIS. No; I have no questions.

Senator JOHNSTON. Senator McClure?

Senator MCCLURE. Mr. Chairman, I have no further questions.

I thank the gentlemen for their testimony today.

Senator JOHNSTON. Thank you very much, gentlemen.

I look forward also to further discussion of SDI later, because there may not be money left for everything. You may have to fire all of your scientists if we go into SDI, and we could not have that.

Admiral FOLEY. I must ask for your very strong support on the issue of testing, sir. I am not optimistic in the House. I think we have major problems in the House.

Dr. BARKER. Senator Johnston, if I may make a comment. I really do appreciate your having these three gentlemen at the table today because they are the ones to whom the country, indeed the Defense Department, looks to tell us that the weapons we have will work. These are the people who have to say that the weapons we have are reliable and will perform as they are supposed to.

You hear an awful lot of other people commenting upon what is needed in order to maintain that reliability. But these three gentlemen have said that we need to continue testing in order to maintain confidence.

Senator JOHNSTON. Well, I do not think we are spending enough money to put in insensitive high explosives on those B–52's.

Admiral FOLEY. I agree with you.

Dr. BARKER. We all agree with that.

Well, we thank you all very much.

DOE LOBBYING REGULATIONS

Senator JOHNSTON. One final item. There are some regulations, I don't know whether they are DOE regulations or DOD regulations, which would, in effect, prevent the Labs from lobbying the Congress. We think scientific and technical advice is very important and for you to be able to fly over here and do whatever other expenses there are.

Would you have any advice to us on whether we should or should not proceed with our tentative plans to write legislation that says you are not prohibited from giving us that scientific and technical advice?

Admiral FOLEY. They are both going to turn and look at me because I got them by the throat. I will tell you the response we have.

I have no problems with scientific and technical advice. I have trouble with individuals in the laboratory doing an end-run and coming on and lobbying for their part of a program, wanting more money to some degree, than the director of the laboratory has already sat down with us and worked out.

I get blind-sided by a congressional supporter coming on into us and saying add this on and do that because you have to restructure the entire program.

I have no problem with technical advice. I do have a problem with them doing lobbying for the budget for specific items after we have already worked it out.

Senator JOHNSTON. Well, we don't object to end runs. [Laughter.]

Dr. BIRELY. Let me state, though, that although I certainly have a lot of sympathy with what Admiral Foley said, I believe that the cure may be worse than the disease. In other words, the current legislation is so restrictive that, for instance, if you called one of us up and said, "How many tests have been done at the Nevada Test Site?" we are not supposed to answer that question. We are supposed to refer to DOE.

Admiral FOLEY. Oh, that is horse manure. Absolute horse manure. [Laughter.]

Dr. BIRELY. According to section 1534, it is so.

Dr. BATZEL. What I want to protect out of this is the ability to talk with you people when it makes sense.

Admiral FOLEY. We agree with that.

Senator MCCLURE. What we want to protect, too, is the ability for us to ask questions and get answers.

Now, I understand your problem, if, indeed, people come to sell a program to us.

But I believe those of us who are elected to office can insist on having information with respect to which we can, if necessary, second guess your decisions.

Admiral FOLEY. I have no problem with providing technical information because I have a grip on the laboratories, and I will tell you, I will come after the lab directors and the specific individuals if I find them end-running in what I would call absolute contravention of what we sat down and worked out, sir.

Senator MCCLURE. But if I ask them a question, I expect them to be able to give me an honest answer.

Admiral FOLEY. And I expect that they will, and I expect to know about it after they do it. [Laughter.]

Senator MCCLURE. And I'll almost guarantee that if they persuade me, they will. You see, there are two ends to this street, and I am sympathetic with your problem and I am not trying to frustrate you.

The other side of that, however, is there are independent judgments which sometimes are made by people who wear political coats in the elective process.

Admiral FOLEY. When it is done in an orderly fashion, sir, I have no objection.

But I will tell you, they work for me and I am going to control them.

Senator MCCLURE. Well, if you control them in ways that says to them that they cannot talk to us——

Admiral FOLEY. Nobody has ever said that.

Senator MCCLURE [continuing]. Well, all I am saying is you said you are going to control them, and I would suggest that if you interfere with our ability to get the information we want, we will control you.

Admiral FOLEY. You misread me. I am talking about end-runs around the budget.

Senator MCCLURE. But I don't want you to misread me.

Admiral FOLEY. Oh, I don't, sir.

That's what I call a Mexican standoff.

Senator JOHNSTON. It's not an end-run. This is the line of scrimmage here. [Laughter.]

SUBCOMMITTEE RECESS

Thank you all. We will now recess subject to call.

[Whereupon, at 4:30 p.m. Wednesday, March 25, the subcommittee was recessed to reconvene at 10 a.m. Monday, March 30.]

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

MONDAY, APRIL 6, 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:30 p.m. in room SD-116, Dirksen Senate Office Building, Hon. J. Bennett Johnston (chairman) presiding.

Present: Senators Johnston, Sasser, Hatfield, and McClure.

DEPARTMENT OF ENERGY

NUCLEAR MATERIALS PRODUCTION

STATEMENT OF SYLVESTER R. FOLEY, JR., ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

Senator JOHNSTON. The subcommittee will come to order.

This afternoon our hearing with the Department of Energy will focus on the need for special nuclear materials for the nuclear weapons program and the situation existing today with our defense reactor capability.

Admiral Foley, Assistant Secretary for Defense Programs, will testify first. Admiral Foley is accompanied by Maj. Gen. Vincent E. Falter, Deputy Assistant to the Secretary of Defense for Atomic Energy; and John Meinhardt, Deputy Assistant Secretary for Nuclear Materials. Mr. Meinhardt will follow Admiral Foley in explaining the program details.

PREPARED STATEMENTS

We will put the full statements in the record. So, Admiral, proceed in your own way as to how you wish to address the committee.

[The statements follow:]

STATEMENT OF ADM. SYLVESTER R. FOLEY, JR., ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

Mr. Chairman. Thank you for the opportunity to testify before this Subcommittee on the need for special nuclear material and the status of our capability to fulfill those needs. Accompanying me today are Major General Vincent E. Falter, Deputy Assistant to the Secretary of Defense for Atomic Energy; and Mr. John Meinhardt, Deputy Assistant Secretary for Nuclear Materials.

The responsibilities of the Department of Energy (DOE) in the area of defense programs stem from the Atomic Energy Act of 1954, as amended. This legislation establishes the Department's responsibility to develop and maintain a capability to produce all nuclear materials required for the defense programs of the United States.

The Nuclear Weapons Stockpile Memorandum (NWSM) is the document by which the President annually authorizes the production and retirement of nuclear weapons. In the memorandum, the Secretaries of Defense and Energy jointly recommend to the President the size and composition of the nuclear weapons stockpile they believe is required to defend the United States. In the development of this memorandum, many factors are considered, such as the needs of the armed services; the current status of legislative actions concerning weapons systems and production capability; and the current status of material inventory, material supply from weapon retirements, material production, and weapons fabrication. Included in the memorandum to the President is the plan for producing the nuclear materials required to support the nuclear weapons stockpile. The NWSM is forwarded to the President through the National Security Council. In accordance with the Atomic Energy Act, approval of the NWSM by the President and subsequent authorization and appropriation of funds by Congress constitute the legal authority and mandate to DOE to produce the specified types and quantities of nuclear materials and weapons. If significant changes occur after the development of an NWSM, such as Congressional action that potentially affects material demand, DOE factors the impact into its implementation of the NWSM requirements after the Department of Defense formalizes the modified requirements.

The current nuclear materials requirements for defense programs come from the FY 1987-1992 NWSM, approved by President Reagan *Deleted* This document defines the annual requirements for defense nuclear materials for the first 6 years (FY 1987-1992) and the planning directives for the next 5-year period.

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The requirements authorized in the FY 1987-1992 NWSM result from efforts to modernize and improve stockpiled nuclear weapons, as well as to provide warheads for new weapons systems scheduled for deployment during the next decade. The program to modernize existing weapons systems involves replacing older nuclear warheads and existing delivery systems with modern, safer, and more effective warheads. Modernization, in many instances, has led to replacing older warheads that used uranium enriched in the isotope uranium-235 with new warheads that use weapon-grade plutonium.

In developing the quantity of new plutonium required from the Department's production reactors, the supply of plutonium from the prompt recycle of material from weapons retirements, from minimizing the weapons manufacturing inventories, as well as from effective processing and recycle of plutonium residues generated in the weapons manufacturing processes is optimized. As a result of special efforts initiated over the past several years in these areas, we project a reduction in the total inventory of plutonium residues by *Deleted* by FY 1992, and efficiencies effected in weapons manufacturing processes have reduced residue generation rates by 40 percent, and further improvements are planned. Despite these improvements and the fact that weapons retirements will provide approximately *Deleted* of the material to be used in new weapons builds over the next 6 years, substantial quantities of plutonium from the production reactors are still required for that period.

Deleted

Our production strategy for tritium is to always produce the quantity required to maintain the existing weapons stockpile and support new weapon production with the remaining reactor capacity devoted to plutonium production. With the recent lower operating power levels in the Savannah River reactors,

Deleted

How have we gotten into this situation? The factors which have contributed to our current problems include:

- o difficulty in maintaining production in aging facilities;
- o the impact on production of construction activities to renovate and upgrade facilities;
- o the impact on production of evolving environment, safety, and health (ES&H) and safeguards and security (S&S) requirements and constraints;
- o the impact on facility operation of an increasingly sensitized public and media environment as a result of Chernobyl and other factors; and
- o the difficulties in maintaining viable production facility operation within a constrained budget while ES&H and S&S funding requirements continue to increase.

Recent experience with the plutonium metal production facility at the Hanford site, the fuel and plutonium metal production facilities at Savannah River, and the reactors at the Hanford site Savannah River, dramatizes the difficulty of maintaining a high level of production in facilities which are 20 to 30 years old. These conditions exist despite efforts over the past several years to restore and upgrade equipment and systems. Frequent equipment failures have reduced facility availability, significantly reducing production. Experience in several of these same facilities where upgrades and modifications were being implemented in parallel with facility operation has shown that in some cases, this approach is not feasible because of congestion, logistics, security, or safety considerations. In some cases, the construction activities have caused a significant reduction in production efficiency.

Evolving ES&H requirements have caused more frequent and lengthy facility shutdowns to implement ES&H upgrades and enhancements and respond to increased regulatory requirements. Furthermore, the operation of many production facilities such as the Savannah River fuel and target fabrication facilities, the Feed Materials Production Center in Fernald, Ohio, and L Reactor is now contingent upon the successful operation of liquid effluent treatment facilities, air cleaning facilities, thermal mitigation ponds, etc. Many more production facilities will be similarly affected in the future. Complying with these ES&H requirements has resulted in significant reductions in production rate, as well as more frequent outages since treatment facility failures result in a shutdown of production. For example, L Reactor production was reduced approximately 20 percent in FY 1986 as a result of thermal mitigation requirements.

All these factors combined resulted in a reduction in actual production from that planned in FY 1986 of *Deleted* for the reactors and *Deleted* for the plutonium processing facilities. We anticipate FY 1987 production will be even more severely impacted as a result of the N Reactor standdown and the power reduction in the Savannah River reactors. Despite our continuing efforts to restore and upgrade our facilities, the probability of production problems in future years remains relatively high.

For this reason, I plan to accelerate activities to assure a viable future nuclear materials production capability. To this end, we will be proposing the initiation of activities on a new production reactor in FY 1988 and we will continue to expedite the development and deployment of the Special Isotope Separation process. The strategic planning study which I initiated shortly after becoming Assistant Secretary will soon be providing the basis for me to propose additional actions to strengthen our future production capability. In the meantime, however, it is essential that the existing base production capability be maintained to provide reasonable confidence that near- and mid-term material requirements can be met to support national defense needs.

If arms control initiatives are successful and material requirements change dramatically, we will revisit the level of production capability which should be maintained just as was done in the

1970's when a large number of production facilities were closed; however, the country cannot afford to forego any portion of the existing production capability before the required executive and legislative branch actions have taken place to modify the planned composition of this country's nuclear deterrent.

I want to thank you, Mr. Chairman, and the rest of the Subcommittee for your attention, and I would be pleased to answer any questions.

STATEMENT OF MAJ. GEN. VINCENT E. FALTER, DEPUTY ASSISTANT TO THE SECRETARY OF DEFENSE FOR ATOMIC ENERGY

MR CHAIRMAN, IT IS A PLEASURE TO APPEAR BEFORE THIS COMMITTEE TO PROVIDE TESTIMONY ON THE ROLE OF THE DEPARTMENT OF DEFENSE (DOD) IN ESTABLISHING REQUIREMENTS FOR NUCLEAR WEAPONS.

THE PURPOSE OF MAINTAINING A NUCLEAR WEAPONS STOCKPILE IS, OF COURSE, DETERRENCE; IN PARTICULAR, DETERRENCE OF SOVIET AGGRESSION OR THREAT OF NUCLEAR BLACKMAIL AGAINST THE UNITED STATES OR OUR ALLIES. THE UNITED STATES MUST CONTINUE TO MAINTAIN A POSTURE THAT CLEARLY DEMONSTRATES TO THE SOVIET UNION, OR ANY OTHER POTENTIAL OPPONENT, THAT HE HAS NOTHING TO GAIN AND MUCH TO LOSE FROM INITIATING AGGRESSION. STRATEGIC AND NONSTRATEGIC NUCLEAR FORCES CONTRIBUTE TO THIS DETERRENT POSTURE. THESE FORCES MUST BE ABLE TO RETALIATE EFFECTIVELY EVEN AFTER A SOVIET FIRST STRIKE.

DOD IS RESPONSIBLE FOR SETTING REQUIREMENTS FOR NUCLEAR WEAPONS--WHAT WEAPONS AND ASSOCIATED FEATURES TO DEVELOP; HOW MANY TO PRODUCE. THE DEPARTMENT OF ENERGY (DOE) IS RESPONSIBLE FOR DESIGNING AND PRODUCING NUCLEAR WEAPONS TO MEET THOSE REQUIREMENTS. WE ARE JOINTLY RESPONSIBLE FOR SAFETY AND SECURITY. I WILL FOCUS UPON THE REQUIREMENTS' PROCESS, I.E., HOW DECISIONS TO DEVELOP NUCLEAR WEAPONS ARE MADE, HOW PERFORMANCE SPECIFICATIONS ARE DETERMINED, HOW THE INDIVIDUAL WEAPON PROGRAMS ARE COORDINATED BETWEEN DOD AND DOE, AND HOW THE REQUIREMENTS ON DOE WARHEAD DESIGN AND PRODUCTION ARE FORMALIZED IN THREE BASIC DOCUMENTS.

THE FIRST STEPS IN SETTING REQUIREMENTS WITHIN DOD ARE THE IDENTIFICATION AND VALIDATION OF REQUIREMENTS. ALL THREE MILITARY SERVICES HAVE FORMAL PROCESSES FOR IDENTIFYING

REQUIREMENTS ON THE BASIS OF MISSION ANALYSIS, AND THEY HAVE REGULATIONS THAT MAKE ANALYSIS THE BASIS FOR VALIDATING REQUIREMENTS WHETHER FOR CONVENTIONAL OR NUCLEAR SYSTEMS. THE NUCLEAR WEAPONS ACQUISITION POLICY, ISSUED BY THE SECRETARY OF DEFENSE, DIRECTS THAT NUCLEAR WEAPONS WILL BE PROCURED ONLY IF THEY PROVIDE A UNIQUE AND SUBSTANTIAL MILITARY CAPABILITY AND CONTRIBUTION TO DETERRENCE AFTER THOROUGH CONSIDERATION OF ALTERNATIVE MEANS OF ACCOMPLISHING MILITARY AND DETERRENCE OBJECTIVES. IF A CONVENTIONAL SOLUTION TO THE REQUIREMENT IS NOT ADEQUATE, THE DOE JOINS IN STUDIES TO DETERMINE IF NUCLEAR SOLUTIONS ARE FEASIBLE.

PHASE 1 (WEAPON CONCEPTION) AND PHASE 2 (DETERMINATION OF FEASIBILITY AND RESPONSIBILITIES) ARE PART OF A JOINT NUCLEAR WEAPON DEVELOPMENT PROCESS AGREED TO BY BOTH THE DOD AND THE DOE. THE TWO PHASES PROVIDE THE INFORMATION NECESSARY TO SUPPORT A DECISION TO ENTER PHASE 3 (DEVELOPMENT ENGINEERING), WHICH IS THE FIRST REAL COMMITMENT TO PRODUCING A NUCLEAR WARHEAD.

A PHASE 1 STUDY DETERMINES WHETHER THERE IS SUFFICIENT JUSTIFICATION IN AN IDEA FOR A NEW WEAPON OR COMPONENT TO WARRANT FURTHER DEVELOPMENT.

A PHASE 2 STUDY EXAMINES THE FEASIBILITY AND DESIRABILITY OF UNDERTAKING THE DEVELOPMENT OF A NEW NUCLEAR WEAPON AND THEN DETERMINES THE RESPECTIVE RESPONSIBILITIES OF DOE AND DOD FOR DEVELOPMENT AND PROCUREMENT. TRADE-OFFS INVOLVING WEAPON FEATURES HAVE BEEN MADE DURING PHASE 2 STUDIES. FOR EXAMPLE, A PHASE 2 STUDY OF THE B83 BOMB DEVELOPMENT MADE CHANGES IN REQUIREMENTS IN ORDER TO REDUCE COSTS. ALSO, A DECISION TO PURSUE A COMMON WARHEAD FOR THE AIR-LAUNCHED CRUISE MISSILE (ALCM) AND SEA-LAUNCHED CRUISE MISSILE (SLCM) WAS MADE IN PHASE 2.

AT THE START OF PHASE 2A (DESIGN DEFINITION AND COST STUDY) DOD ESTABLISHES A PROJECT OFFICERS GROUP (POG) TO COORDINATE THE DOD/DOE TECHNICAL INTERFACE IN NUCLEAR WEAPON DEVELOPMENT PROJECTS. A POG, CHAIRED BY A LEAD PROJECT OFFICER FROM THE COGNIZANT MILITARY SERVICE, HAS MEMBERS FROM BOTH DEPARTMENTS. ALTHOUGH IT ACTS IN MANY WAYS LIKE A PROGRAM OFFICE, IT DOES NOT DIRECT DEVELOPMENT. IN PHASE 2A, A POG FOCUSES ON DEFINING THE BASELINE SYSTEM AND CONDUCTING REQUIREMENT-TRADE-OFFS TO SUPPORT A DECISION TO ENTER PHASE 3. LATER, ONCE ENGINEERING DEVELOPMENT HAS BEGUN, IT FOCUSES ON MORE DETAILED TRADE-OFFS INVOLVING SPECIFIC DESIGN CHANGES. EXPERIENCE HAS SHOWN THAT THIS ARRANGEMENT WORKS WELL FOR WEAPON DEVELOPMENT.

A PHASE 3 IS INITIATED BY A REQUEST, BY THE DEPUTY SECRETARY OF DEFENSE, TO THE DEPARTMENT OF ENERGY TO JOIN THE DEPARTMENT OF DEFENSE IN THE PROJECT. THIS REQUEST INCLUDES DRAFT MILITARY CHARACTERISTICS (MC) AND STOCKPILE TO TARGET SEQUENCE (STS). THE MC AND STS ARE TWO OF THE THREE REQUIREMENTS DOCUMENTS ON DOE-DESIGNED WARHEADS.

THE MCS STATE THE PERFORMANCE REQUIREMENTS AND PHYSICAL CHARACTERISTICS OF THOSE PARTS OF A NUCLEAR WEAPON THAT ARE THE SOLE RESPONSIBILITY OF THE DOE TO DESIGN, DEVELOP, CERTIFY, AND PRODUCE. MCS ARE FIRST DRAFTED DURING PHASE 1 STUDIES, EVOLVE THROUGH PHASE 2 AS A STATEMENT OF DESIRED DOD PERFORMANCE OBJECTIVES, AND BECOME DESIGN REQUIREMENTS ONLY AFTER FORMAL DOE ACCEPTANCE EARLY IN PHASE 3.

THE STS SUPPLEMENTS THE MCS BY DESCRIBING THE LOGISTICAL AND OPERATIONAL CONCEPTS FOR THE WEAPON SYSTEM AND THE RESULTING PHYSICAL ENVIRONMENTS THAT THE NUCLEAR WEAPON CAN ENCOUNTER. THE STS IS DEVELOPED THROUGH AN EVOLUTIONARY PROCESS BEGINNING IN PHASE 1 AND IS A "LIVING" DOCUMENT THAT IS REVIEWED

CONTINUOUSLY AND REVISED AS REQUIRED THROUGHOUT THE LIFE OF A NUCLEAR WEAPON PROJECT.

CHANGES TO THE STS WILL BE APPROVED BY THE POG AND WILL BE PUBLISHED BY THE COGNIZANT MILITARY DEPARTMENT. THE COGNIZANT MILITARY DEPARTMENT WILL INFORM THE NUCLEAR WEAPONS COUNCIL (NWC), BEFORE APPROVAL, OF CHANGES THAT MAY REQUIRE SIGNIFICANT ADDITIONAL RESOURCES OR DELAY INITIAL OPERATIONAL CAPABILITY.

THROUGH THIS PROCESS, THE MCS AND STS BECOME REQUIREMENTS DOCUMENTS WHICH INFLUENCE THE DESIGN OF A SPECIFIC WARHEAD AND ITS RESULTING USE OF SPECIAL NUCLEAR MATERIAL (SNM). THE THIRD REQUIREMENTS DOCUMENT, THE NUCLEAR WEAPONS STOCKPILE MEMORANDUM (NWSM) ADDRESSES QUANTITIES OF ALL NUCLEAR WARHEADS IN OUR STOCKPILE.

AMONG THE CONSIDERATIONS THAT ARE INCLUDED IN THE DEVELOPMENT OF THE NWSM ARE MILITARY JUDGMENT (THROUGH THE JOINT CHIEFS OF STAFF AND COMMANDERS-IN-CHIEF (CINCS) OF THE UNIFIED AND SPECIFIED COMMANDS), OUR ALLIES' REQUIREMENTS FOR NUCLEAR SUPPORT THROUGH PROGRAMS OF COOPERATION, REQUIREMENTS BASED ON FORMAL OPERATIONAL PLANS (SUCH AS THE SINGLE INTEGRATED OPERATIONAL PLAN AND THE STRIKE PLAN OF THE SUPREME ALLIED COMMANDER, EUROPE), DELIVERY SYSTEMS AVAILABILITY, AND BUDGET CONSTRAINTS. THE UNIFIED AND SPECIFIED COMMANDS ARE ASKED ANNUALLY TO DEFINE THE FORCES NECESSARY TO ENSURE SUCCESS IN THEIR MISSION. THE JOINT CHIEFS OF STAFF (JCS) ARE TASKED TO INTEGRATE THESE REQUIREMENTS IN A WORLDWIDE BASIS AND RECONCILE THE PROPOSED FORCES WITH THE SERVICES' BUDGETS TO ACQUIRE THESE FORCES. THIS PROCESS STARTS WITH THE CINCS MINIMUM RISK FORCE. THIS FORCE, AND ASSOCIATED STOCKPILE, GIVE THE CINC VIRTUAL ASSURANCE OF SUCCESS. BY REDUCING REDUNDANCY, THIS FORCE IS

REDUCED TO THE PLANNING STOCKPILE. THIS IS THE FORCE INPUT TO THE DEFENSE GUIDANCE. THE SERVICES THEN PREPARE THEIR PROGRAM OBJECTIVE MEMORANDA AND THE JCS DERIVES THE FISCALLY CONSTRAINED FORCE. THIS FORCE IS PROVIDED TO THE OFFICE OF THE SECRETARY OF DEFENSE AS INPUT TO THE NWSM. THE FORCE IS FURTHER REDUCED BY POLITICAL CONSTRAINTS AND DOE PRODUCTION CAPABILITIES. THIS FINAL FORCE IS THE ONE REPRESENTED IN THE NWSM, WHICH IS SUBMITTED BY THE SECRETARIES OF DEFENSE AND ENERGY TO THE PRESIDENT FOR HIS APPROVAL.

PRODUCTION QUANTITIES OF NUCLEAR WARHEADS FOR ASSOCIATED SYSTEMS (INTERCONTINENTAL BALLISTIC MISSILES, SUBMARINE-LAUNCHED BALLISTIC MISSILE, AIR-TO-SURFACE MISSILES, AND LONGER RANGE INTERMEDIATE NUCLEAR FORCES) RELATE IN A STRAIGHTFORWARD WAY TO THE NUMBER OF DELIVERY SYSTEMS PLANNED FOR DEPLOYMENT. THE RATIONALE AND DETAILED PLANS FOR SYSTEMS IN THE PRESIDENT'S STRATEGIC MODERNIZATION PROGRAM ARE PROVIDED IN PRESIDENTIAL AND DOD POSTURE AND BUDGET STATEMENTS. IN CONTRAST, PRODUCTION QUANTITIES FOR NON-ASSOCIATED NUCLEAR FORCES CANNOT BE DERIVED SOLELY FROM THE NUMBER OF AVAILABLE DELIVERY SYSTEMS, SINCE MANY OF THE DELIVERY SYSTEMS ARE DUAL CAPABLE--BOTH CONVENTIONAL AND NUCLEAR (FOR EXAMPLE, THE AIRCRAFT-DELIVERED SYSTEMS AND THE ARTILLERY FIRED ATOMIC PROJECTILES). FOR THESE SYSTEMS, THE INVENTORY REQUIREMENTS ARE DRIVEN MUCH MORE BY DETAILED OPERATIONAL AND SURVIVABILITY REQUIREMENTS THAN BY NUMBERS OF DELIVERY SYSTEMS. DETERMINING THESE NUMBERS IS A MATTER OF DETAILED ANALYSIS LEAVENED BY POLITICAL-MILITARY JUDGMENT THAT CONSIDERS THE GROWING CAPABILITIES OF THE PACT FORCES. IN THIS CONTEXT, NUCLEAR SUPPORT OF OUR ALLIES IS A SIGNIFICANT FACTOR IN DETERMINING OVERALL REQUIREMENTS, AND DEPLOYMENT AND RETIREMENT ACTIONS.

THE ATOMIC ENERGY ACT, WHICH REQUIRES THE PRESIDENT TO APPROVE PRODUCTION OF NUCLEAR WEAPONS AT LEAST ONCE A YEAR, IS THE STATUTORY BASIS FOR THE NWSM. THE NWSM PROVIDES THE NUCLEAR WEAPON STOCKPILE REQUIREMENTS FOR THE CURRENT YEAR AND THE SUBSEQUENT FIVE YEARS ASSOCIATED WITH THE FIVE YEAR DEFENSE PLAN. A PROJECTION FROM THE SEVENTH THROUGH THE SIXTEENTH YEAR IS ALSO PROVIDED. THE NWSM ADDRESSES THE AVAILABILITY OF SNM, ESPECIALLY IN RELATION TO THE PROPOSED STOCKPILE IN THE OUT YEARS. THE PRESIDENT APPROVES THE NWSM AND DIRECTS THE NECESSARY STEPS FOR IMPLEMENTATION BY ISSUING A NATIONAL SECURITY DECISION DIRECTIVE.

I WOULD LIKE TO CLOSE BY STATING THAT THE REQUIREMENTS PROCESS WORKS WELL. DURING THE LAST TWENTY YEARS, THE NUMBER OF WEAPONS IN THE NUCLEAR STOCKPILE HAS BEEN REDUCED BY ONE-FOURTH, AND THE TOTAL YIELD (DETONATION ENERGY) OF THE STOCKPILE HAS DECLINED EVEN MORE STRIKINGLY BECAUSE WE HAVE WITHDRAWN MANY LARGE, HIGH YIELD WEAPONS. AS A RESULT, THE TOTAL MEGATONNAGE OF OUR NUCLEAR WEAPONS HAS BEEN REDUCED BY 75 PERCENT SINCE 1960. SIGNIFICANTLY, THIS REDUCTION IN NUMBERS AND MEGATONNAGE WAS ACCOMPLISHED EVEN IN THE FACE OF A MAJOR INCREASE IN THE NUMBER OF SOVIET HARD TARGETS.

THE POLICY OF THIS ADMINISTRATION HAS BEEN, AND CONTINUES TO BE, THAT NATIONAL SECURITY REQUIREMENTS, NOT PHYSICAL CONSTRAINTS ON SPECIAL NUCLEAR MATERIAL (SNM) AVAILABILITY, SHALL BE THE LIMITING FACTOR IN NUCLEAR FORCE STRUCTURE. IF UNFORESEEN EVENTS INTERRUPT SNM AVAILABILITY SUCH THAT REQUIREMENTS OF THE PRESIDENTIALLY-APPROVED NUCLEAR WEAPONS STOCKPILE MEMORANDUM CANNOT BE SUPPORTED FULLY, OPTIONS WILL BE CAREFULLY REVIEWED BY THE JOINT NUCLEAR WEAPONS COUNCIL. THESE OPTIONS WILL INCLUDE, OF COURSE, ACTIONS WHICH MIGHT BE TAKEN BY BOTH DEPARTMENTS TO MINIMIZE IMPACTS TO OUR DETERRENT POSTURE.

THIS CONCLUDES MY FORMAL TESTIMONY. I WOULD BE PLEASED TO ANSWER ANY QUESTIONS.

NUCLEAR MATERIALS PRODUCTION PROCESS

Mr. FOLEY. Thank you very much, Mr. Chairman.

I have a statement for the record. You have already indicated those would be accepted, so rather than go through that in some detail, my intention would be to just say a few words and defer to my deputy, John Meinhardt, who will cover the specifics, and then I think the iteration back and forth of questions and answers should resolve any inconsistencies or any uncertainties that we may have.

The Department of Energy responsibilities, of course, come from the Atomic Energy Act. Materials requirements are determined in the President's stockpile memorandum, which is submitted to the President once a year by the Department of Defense and the Department of Energy, jointly—each Secretary signing off—goes to the National Security Council. It is well scrubbed there, of course, through the draft process. Then it proceeds on up and is signed off by the President. That is our marching orders for the given year.

It walks out through, I believe it is a half-dozen years of detail and then a projected 5 years on after that. But that is the Bible, if you will, by which we produce the weapons and the materials, the special nuclear materials, to meet the requirements as established by the Department of Defense. Now that is the general process that goes on over a year's period of time.

As there are changes due to the dynamics of the reactors, perhaps where you might have to throttle back a little bit or you have to make some changes, then this gets worked between the Department of Defense and the Department of Energy so that there is an ongoing process throughout the entire year to establish the requirements and to meet them on our part. A little give and take on the number of weapons that come out, the number of turn-ins, which particular type, that sort of process goes on.

Now having made that sort of general statement on the process, let me turn now to my deputy, John Meinhardt, to go into much more detail.

STATEMENT OF JOHN L. MEINHARDT, DEPUTY ASSISTANT SECRETARY FOR NUCLEAR MATERIALS, DEPARTMENT OF ENERGY

Mr. MEINHARDT. Mr. Chairman, I do not have a prepared statement, and rather, with your permission, I would like to just stand up and talk through the program using some viewgraphs.

Senator JOHNSTON. All right, proceed.

TRITIUM PRODUCTION

Mr. MEINHARDT. Sir, the way I understand your concern this afternoon is to try to justify and see what continues to drive the need for reactor products. Now reactor products that I am going to address specifically this afternoon are tritium, which is a gas, and plutonium,which is a metal.

Now tritium is in each warhead—we are in a classified hearing, right?

Senator JOHNSTON. Right.

Mr. MEINHARDT. All right.

[Chart deleted.]

The amount of tritium in each warhead varies depending upon the class or the type of warhead it is, and typically it is on the order of [deleted]. But tritium decays. It has a half-life of 12½ years. It must continue to be replenished in the stockpile. It is the material that is used to boost weapons to achieve a thermonuclear yield.

[Deleted.] But the real issue is that it is absolutely critical to the efficacy of the stockpile that it continue to be replaced.

Now we only produce tritium in one location within our complex and that is at Savannah River. Typically, at Savannah River, we have one reactor operating on tritium when that reactor can operate at full power. You have no doubt read the papers recently and know that we are not operating currently at full power at Savannah River, and I will talk about that a little bit more later.

But, typically, you have one reactor continuously on tritium. About every fourth year you must put a second reactor on to maintain the necessary inventory. It so happens that at this point in time we were scheduled to have two reactors on tritium because that was the normal cycle. Now, unfortunately, because we are in a power reduction—because of another issue—I only have two reactors operating on a tritium cycle. Therefore, it is really effective only as——

Senator JOHNSTON. Where is the other reactor?

Mr. MEINHARDT. The other reactor is L reactor and that operates on plutonium continuously.

Senator JOHNSTON. Where is L reactor?

Mr. MEINHARDT. That is also at Savannah River.

Senator JOHNSTON. Also at Savannah River. So both tritium reactors are at Savannah River?

Mr. MEINHARDT. That is right. Now the L reactor technically can produce tritium. Unfortunately, at the current time the environmental impact statement for L reactor may not cover tritium production.

Senator JOHNSTON. The environmental impact statement?

Mr. MEINHARDT. That is right. On the L reactor it may not cover the production of tritium in that reactor.

Senator JOHNSTON. Well now, do you regard that as being a formality or a matter of real substance?

ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

Mr. MEINHARDT. It is a matter of formality that when we do, and we are reviewing what is required from a National Environmental Policy Act standpoint to allow tritium production. It would be an amendment to the EIS, as I understand it.

Senator JOHNSTON. I thought that military needs did not have to go through environmental impact statements.

Mr. MEINHARDT. Not so with respect to——

Senator JOHNSTON. Not so with respect to reactors?

Mr. MEINHARDT. No, sir. Any of our facilities, major facilities, if they have an impact on the environment, we must go through the EIS process. Every new facility that we are deploying within the complex we are taking EIS actions on.

Senator JOHNSTON. Well, is there a difference between the impact on the environment with tritium than with uranium or plutonium, or whatever?

Mr. MEINHARDT. A difference between tritium and plutonium? Not really a substantive difference with respect to the environment. Not really. In plutonium, it may be a little bit greater than tritium if you consider all the waste streams and processing that is required to extract that product.

As I said, tritium is a gas. It is held up in a target, and it is simply extracted through a heat process and loaded in bottles. It is a relatively benign activity.

The fact of the matter is, I want to show you what we are talking about with respect to a rod at Savannah River. This is a rod that is about 15 feet or so. This is a cross section. In order to produce tritium, you have an outside tube that contains lithium, and you have an inside tube that contains lithium. These would be about 80 percent highly enriched uranium. And you irradiate that lithium, creating tritium, and then this, in turn, is put into a furnace and heated, and the tritium is driven off as a gas, and collected, purified, and then placed in——

Senator JOHNSTON. But initially it is a solid?

Mr. MEINHARDT. Yes; and this is a cladding that goes around the lithium material. This particular section is made up of two tubes filled with lithium in between and capped off.

This outer ring and this inner ring are the ones from which you are creating a tritium gas.

Senator JOHNSTON. I mean the gas shows up only when you put it in the heat.

Mr. MEINHARDT. In the neutron radiation; yes, sir. It is literally trapped in here until such time as you drive it off with heat in the extraction facility.

Senator HATFIELD. Is that the same lithium they use for mental depression, in the medical drug?

Mr. MEINHARDT. Yes.

Senator HATFIELD. Is it the same thing they use in mental health?

Mr. MEINHARDT. Like Valium or whatever that is.

Senator HATFIELD. For depression, I think, like a mental illness.

Mr. MEINHARDT. Yes, sir.

The real important thing to understand with tritium, however, is its absolute essentiality with respect to the stockpile. You need to have the ability to replace those bottles on a regular basis, which typically, even though it has a 12½ year half life, [deleted]. But the yield of your stockpile would literally go down [deleted] if you did not replace the bottles.

PLUTONIUM REQUIREMENTS

The second set of bullets here, these four, deal with plutonium. The first one is that we are on a new program to improve and modernize the stockpile in terms of safety.

DEFENSE PROGRAMS—NUCLEAR MATERIALS

DRIVERS FOR REQUIREMENTS

- TRITIUM TO REPLACE THAT LOST THROUGH RADIOACTIVE DECAY
- IMPROVING WEAPONS SAFETY THROUGH NUCLEAR DESIGN
- TRANSITION OF STOCKPILE FROM HEU WEAPONS TO PU WEAPONS
- INCREASING NUMBER OF REENTRY VEHICLES PER MISSILE
- INCREASED MATERIALS USAGE [Deleted.]

Now that safety issue typically involves the use of an insensitive high explosive [IHE] rather than a conventional high explosive [HE] material. That permits the handling of weapons, the movement of weapons, the logistics supply train, even the assembly of weapons to be carried out in a much safer way.

But having said that, that material is less energetic than the HE. And you have to compensate in terms of the volume of HE used, [deleted].

Senator JOHNSTON. Do you have a program now that replaced all the gravity bombs with insensitive high explosives?

Mr. MEINHARDT. [Deleted.] The B-83 is an IHE weapon. The fact of the matter is, currently, the only weapons we are either building or propose to build with HE would be the [deleted]. And the reason for that is because of their size. We cannot squeeze enough IHE into those warheads to make them operate.

[Deleted.]

PLUTONIUM USAGE

Mr. MEINHARDT. The other big driver in terms of plutonium usage is the fact that we are transitioning the stockpile and have been doing that for some amount of time from the old uranium weapons into plutonium weapons. Now in doing that, again that is a safety issue. It is a tailoring issue. You are tailoring the weapons to better fit what the military requirement is. And there was a tremendous inventory, as you may recall, back in the 1960's timeframe during which the stockpile was much larger than our current stockpile. In fact, we are down about 25 percent from those days. But those were predominantly uranium-bearing weapons. We are now recycling them through the stockpile, and building the equivalent militarily effective warhead, using plutonium. That will continue. There is still a good number of those weapons out in the stockpile; i.e., some of those earlier AFAP's and some of the W-31's, which has many, many applications, in the military stockpile.

Now the other issue that is driving us is the number of reentry warheads per missile. You are well aware that the MX which we are building now has 10 warheads. We are eventually going to pull the Poseidon back out of the inventory. And even though that had a [deleted] that will be replaced with the Trident 2, which only has a [deleted].

So the sum of that exchange out though is indeed——

Senator JOHNSTON. I thought the Trident II was an [deleted].

Mr. MEINHARDT. [Deleted.]

Is that about it, General?

General FALTER. [Deleted.]

Mr. MEINHARDT. [Deleted.]

Then there is also the issue of special effects weapons, tailored weapons. You know, as we are increasing the guidance system accuracy with respect to our warheads, we can also come down in yield, but at the same time there are requirements for weapons [deleted].

[Chart deleted.]

The real issue is that through time if you look at the chart, [deleted]. [Chart deleted.] And this reflects, as I said, the transition from basically a uranium weapon in this time period. As we are improving safety, and you can also see that the curve is becoming fairly flat in that the typical warhead now will [deleted].

I would like to now switch over to the reactor status.

Senator HATFIELD. Mr. Chairman, before we move from that point, isn't it factored in a very small number of warheads compared with the increase in plutonium? I mean, that looks like a rather steep line. But have you factored in the fact that you are now planning fewer weapons?

Mr. MEINHARDT. Well, this chart simply represents the average amount of plutonium in an average warhead. Relative to your question, we should wait until we get to the total supply and demand curve. This is just an average amount of plutonium in an average warhead that is out in the stockpile. If you sum them all up, divide by the number of tons of materials we have, you will end up with about [deleted].

Senator HATFIELD. But if you counted the number of warheads, say, as of a certain day than what you had projected, that——

Mr. MEINHARDT. The average is going to stay very close to that warhead right now.

Senator HATFIELD. Per warhead?

Mr. MEINHARDT. Per warhead. The average will stay about there.

Senator HATFIELD. What about the aggregate amount?

Mr. MEINHARDT. That will change. And we will get to a chart on that.

Senator HATFIELD. All right.

[Chart deleted.]

SUPPLY/DEMAND

Mr. MEINHARDT. Maybe I will go directly to that chart now. This is—if I could take just a minute to explain this chart. This represents the demand as we currently understand it from the stockpile memorandum that Admiral Foley spoke of. This blue line represents the total amount of material that we would require to have in the inventory if we were to deliver to the DOD the weapons that we are currently building or projected to build over this 15-year timeframe.

The red line here represents the amount of material that we can, in fact, produce, assuming that we have the operation of N Reactor, that we have at least one reactor at Savannah River on plutonium—and in 3 of the 4 years we will have two on plutonium—plus the recycle of scrap material which we have been doing for some time.

[Chart deleted.]

Mr. MEINHARDT. This total figure here, the [deleted] material now available to the system, or about that amount, includes that which is deployed out in the stockpile, as well as that which is in process. If there is an in-process problem, whenever you are building you must have a working inventory.

We have a fair amount of scrap that falls into several different categories, which we are continuing to recover on an annual basis. But I also must point out to you that as long as we are in production we are also creating scrap. Even though we are aggressively trying to reduce that inventory, we are at the same time, through the manufacturing process, creating scrap.

Senator MCCLURE. Could I ask a question in that regard? What happens to the plutonium you take out of an old weapon?

Mr. MEINHARDT. That becomes recycled into the stockpile.

[Deleted.]

[Chart deleted.]

Mr. MEINHARDT. You have to look at it on a campaign basis. And here is the reason for that. You continually get changes in terms of the amount of material that is retired from the DOD.

You can see here. And this represents the aggregate amount of material that is going out the door every year in new weapons. This is the amount that is coming back from the stockpile [indicating].

Now you can make a point that, why don't you bring these in a little bit sooner and then you wouldn't need so much new. But the problem is, as you roll over these systems in the stockpile you cannot simply bring them all back. You can't say, for example, give me all the Poseidons now so 5 years later I can give you Trident II's. You would be impinging on the war-fighting potential of the United States if you do that.

So there is that inventory management, or system management kind of problem, and it particularly becomes complicated when you deal with the Navy because you must do a boat at a time. And that represents a substantial number of warheads. For example, to load out a Trident-class submarine, you are talking about 24 missiles at 8 warheads apiece, that is a lot of plutonium that you must deliver before you can retire the Poseidons.

RECYCLE OF PLUTONIUM

Senator Johnston. So what do you have to do to that recovered plutonium? How do you recycle that?

Mr. Meinhardt. The weapon is disassembled at our Pantex plant and the pit, the plutonium-bearing pit, is returned to Rocky Flats, a plant near Denver, Colo. And the first thing you do is you run that through a molten salt extraction. And the reason for that is, as plutonium is out in the stockpile, through time, Americium–241 builds up. And that is a bad actor in terms of weapons handling. [Deleted.] So you must extract that Americium–241 out of the material.

Senator Johnston. Is that difficult to do; expensive?

Mr. Meinhardt. The one thing I can say about this business, sir, all of it is expensive. All of it. Everything you do is expensive.

But at any rate, it is a necessary thing you must do, is to go back to metal and then recycle into the manufacturing process.

Senator Johnston. But this is not as big a thing as reprocessing, is it?

RECOVERY AND RETIREMENTS

Mr. Meinhardt. No; it is reprocessing in effect, but it is a very specialized kind of reprocessing. And it is done routinely. I mean, we know how to do this. And in most weapons it is relatively easy. [Deleted.] And then that has to be cleaned up, and, many times, that has to go through a different chemical process than simply the molten salt extraction.

And all of that is a fairly complex chemical process. And, of course, we want to control the purity and uniformity of the components of the metal, in the stockpile for a very good reason.

We do a lot of tests through time out in Nevada, but if you look at that on a statistical basis, that is a very few data points. And so you want to keep the same purity, the same components, and the same balance within the material you put out in the stockpile as those tests are based on.

If you take a test, and it has this kind of metallic content in it, in order to really prove the limits of how far, let's say, how much [deleted] contamination could you really live with, it would take a tremendous number of tests in order to get that—to establish those parameters.

Not being able to do that because of resources, and time and other things, we try to keep that very, very narrow, and keep the purity of that stream through the complex. [Deleted.] Because you have to do that or else you would void the experience you built up through the test program.

Senator Hatfield. Mr. Chairman, could I follow up on Senator McClure's question on retirements?

Senator Johnston. Yes.

Senator Hatfield. I am not sure I fully understand your response to Senator McClure. As I understand it, from about 1980 to 1982, we recovered [deleted] metric tons from retirements, and that 1989 is projected at [deleted].

Now in order to understand the plutonium supply problem, it seems to me that it might be helpful to the committee if we had a list of the retirements that are projected between now and, say, the year 2000, or 1997, 1998, whatever your chart shows, by both the amount of projected recovery of plutonium from those retirements and by weapons class, or identification, because—are you saying to Senator McClure that this great variability in retirements is due entirely to the kinds of weapons that you are retiring?

Mr. MEINHARDT. No, sir; not entirely, sir. The kind of weapons that are being retired also is important. I don't know the numbers off the top of my head. For example, you cited this particular year. What I suspect is that there may not be just a few weapons being retired. It probably says that of those weapons being retired, not all of them, or a relatively small amount of them, are plutonium-bearing weapons.

Senator HATFIELD. Well let's just stick with plutonium, because the figures that I have, that I understand, is that we recovered [deleted] from 1980 to 1982. Now, obviously, those are from weapons that are plutonium components.

As I understand it, we are projecting [deleted] recovery in 1989. [Deleted.] And it seems to me there ought to be some reasons for that schedule, or whatever, has caused that variability.

Mr. MEINHARDT. We can provide that information to you, sir.

Senator HATFIELD. Yes. For the record. I am not asking you to pull it off the top of your head.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. But it does, Mr. Chairman, I think, make an important difference here on the rates of retirement of the plutonium weapons.

[The information follows:]

RETIREMENTS

The plutonium recovered from retirements is a function of the number and types of warheads being retired each year. In general, all but a few percent of the plutonium in retired weapons is recovered and used in new builds. As with plutonium required for new builds, retirements in some years are higher than others. Over the 16-year period from fiscal year 1982 to fiscal year 1997, shown in the following table, retirements are expected to average [deleted] metric tons per year. There are several years—fiscal year 1983, fiscal year 1988, and fiscal year 1989—where annual retirements provide [deleted] metric ton. However, there are also years—fiscal year 1995 and fiscal year 1996—where material from retirements is expected [deleted] metric tons. Retirements in fiscal year 1981 also [deleted] metric tons. The projection stops with fiscal year 1997 because that is the last year for which we have a coordinated Department of Energy/Department of Defense stockpile projection.

NUMBER OF RETIRED WARHEADS WHICH CONTAIN PLUTONIUM—FY 1982 TO FY 1986 ACTUALS AND FY 1987 TO FY 1997 PROJECTED

Fiscal year	Strategic offensive	Strategic defensive	Theater	Fleet	Total
1982					
1983					
1984					
1985					
1986					
1987					
1988			[Deleted]		
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					

PLUTONIUM RETURNED IN RETIRED WARHEADS—FY 1982 TO FY 1986 ACTUALS AND FY 1987 TO FY 1997 PROJECTED

[In metric tons]

Fiscal year	Strategic offensive	Strategic defensive	Theater	Fleet	Total
1982					
1983					
1984					
1985					
1986					
1987					
1988			[Deleted]		
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					

Mr. MEINHARDT. Here you can see it is roughly [deleted] if you look at the 1987–97 time period. You are getting [deleted] metric tons back from retirement [deleted] for new builds.

Senator HATFIELD. Because [deleted] you are projecting a surplus.

Mr. MEINHARDT. Yes; that's right. [Deleted] if you believe this curve [indicating], we should be at a surplus condition. That's providing I can operate my reactors at Savannah River at 100-percent power.

[Chart deleted.]

Mr. MEINHARDT. And as I will show you here, which is rather dramatic, but I have to operate N Reactor to do this. If I don't operate N Reactor then this is the kind of condition that we are in. [Deleted.]

This line represents the amount of material I would have without operating N Reactor [indicating].

Senator HATFIELD. Mr. Chairman, I hate to interrupt again, but your charts before have incorporated a number of other factors. You have only three in this particular chart. I have one here from a year ago, or a few years ago, that includes the retirements, includes the Savannah River reactors, includes the special isotope separation [SIS] technology, and it includes the blending, and so forth.

Mr. MEINHARDT. This is the same type of chart, sir.

Senator HATFIELD. Those other factors in that previous chart change that much?

Mr. MEINHARDT. Anything you see below this curve [indicating] represents the input from SIS. This is the same chart. It just has that breakout that you are speaking of, right here [indicating].

Now the way you can get at the same chart that I said when we were [deleted] this is the N Reactor contribution [indicating]. The C reactor is shut down. This is if N Reactor discontinued operation in January 1987, which is our current provision. And we have SIS coming on line in 1996 and the reference schedule, meaning their normal schedule for Savannah River.

There is something different here on this number [indicating]. The N Reactor contribution, which shows [deleted] looks different.

Senator HATFIELD. Is that the same?

Mr. MEINHARDT. No; it isn't.

Senator HATFIELD. The N Reactor contribution shows here——

Mr. MEINHARDT. Oh, I'm sorry; the N Reactor is down in 1987.

Senator HATFIELD. That is what I thought.

Mr. MEINHARDT. That's right. If I could operate N then this line would be up here [indicating].

Senator JOHNSTON. Can we get that measurement put down in terms of metric tons?

Mr. MEINHARDT. Yes, sir.

[The information follows:]

[Information supplied for the record has been deleted.]

Senator MCCLURE. What is the date on this chart?

Mr. MEINHARDT. This is fresh. This is March 30.

Senator MCCLURE. March 30?

Mr. MEINHARDT. Yes, sir; and this is the same chart. You can see that [deleted]. And this, if I have N up and operating [deleted].

Senator MCCLURE. I am not paranoid, but I cannot read that. Does that show any slippage in SIS?

Mr. MEINHARDT. No, sir.

Senator MCCLURE. I cannot quite draw my vertical line.

Mr. MEINHARDT. We intend to have the SIS starting to contribute material to the stockpile in the 1995 timeframe.

Senator MCCLURE. That is the same as you had projected earlier?

Mr. MEINHARDT. Yes, sir.

Senator MCCLURE. Thank you, Mr. Chairman.

DEFENSE PROGRAMS—NUCLEAR MATERIALS

REACTOR STATUS

- N REACTOR AT RICHLAND, WASH., IN STANDDOWN STARTING JANUARY 7, 1987
- SAVANNAH RIVER REACTORS OPERATING ON ECCS POWER LIMITS (50-60% POWER) STARTING MARCH 20, 1987

STATUS OF MATERIAL PRODUCTION REACTORS

Mr. MEINHARDT. I would like to cover for a moment, sir, the status of our reactors at Savannah River and also N Reactor. You are quite aware that N is down and has been down since the first month of this year. The Department intends to restart that reactor in July. We have an accelerated safety enhancement plan in being for that reactor to try to accommodate some of the recommendations from some of the 50-some people that looked at that reactor since the Chernobyl incident.

We have had a design review of the reactor. We have had a review of N Reactor with respect to graphite fires. We have had a technical safety appraisal.

Senator Hatfield, some distinguished technologists from your state looked at the safety of N Reactor, as well as the panelists referred to as the Roddis Panel, which is really six independent experts, that rendered their opinions with respect to N Reactor. And right now we have the National Academy of Sciences and Engineering looking at all of our class A reactors within the Department, and they are again going to comment to us with respect to the safety of N Reactor, and specifically on the issue of hydrogen buildup mitigation.

Now that issue has gotten a lot of press because there were a couple of those independent experts who suggested strongly that we should install some sort of hydrogen buildup mitigation system in N Reactor. We will, by July, have a hydrogen monitoring system installed. However, the issue of hydrogen buildup mitigation probably cannot be resolved until a December timeframe.

I want to point out that of those 50-plus people that looked at it, no one really said it was unsafe. The fact of the matter is that two people who are most often quoted, Professor Lewis, as well as Mr. Roddis, did not really come out and say it was unsafe. They said it should not be operated unless we need the plutonium. And I hope I have convinced you, at least at this point in time, that there is a need for the plutonium in order to satisfy the currently understood DOD requirements. And, indeed, in my judgment, there is.

CHERNOBYL REACTOR SIMILARITIES

Senator JOHNSTON. Will you tell us the similarities and the differences with the Chernobyl reactor?

Mr. MEINHARDT. The similarities are very few. The fact of the matter is that the N Reactor and the Chernobyl reactor are both graphite-moderated reactors. And from that point there is a significant departure in terms of how those two reactors are conceived.

Where the Soviets really got into trouble was the design of the reactor has a positive void coefficient which basically means that when you get a condition that is running out of control, it tends to compound itself. Where our reactor, N Reactor, has a negative void coefficient. And when you get a condition which could lead you to a meltdown, the system is designed such that it tends to shut itself down. And that is where they really got into trouble. They were running an experiment which, very frankly, would never have been approved by anybody on our side of the fence, be they safety experts or reactor operators.

It was, in retrospect, a rather ambitious and very, very dumb experiment. And in so doing, they literally lost control of that reactor. It compounded itself and obviously resulted in a very catastrophic accident.

Now I have got a model here of N Reactor. I don't know if you have ever seen that or not. But a couple of the things I might point out are different.

The first thing is, this is the core of the reactor. And we load tubes horizontally into that reactor about a third, every 30 days, and then they are pushed out the back end and go down into a pool. And they contain the plutonium. That plutonium then is taken to a facility to extract it.

The Soviet reactor, on the other hand, has vertical tubes, not horizontal tubes. Our control rods, which are represented here on the sides [indicating], we can drive them in and out in something under 1½ seconds. That is probably a factor of four or five faster than what the Soviet reactors could do, which were driven vertically.

In addition to these horizontal control rods, we have a ball system. If you ever lose power in the reactor or the primary system fails to operate, then a hopper that contains boron balls will automatically open. And the boron balls drop down in chutes throughout the reactor, and that essentially absorbs the neutrons and shuts the reactor down. It is a fail safe shutdown system.

We also have monitors on all the tubes. We monitor temperature and pressure on every tube. The Soviet reactor did not have that kind of a provision.

In the press in the Northwest, when N Reactor is operating, you find very often that you pick up the paper, "N Reactor is shut down. N Reactor has scrammed." We have an automatic scram system on the reactor. In fact, we have so many automatic trip signals, it scrams a lot. As a result, we have a higher frequency of scrams.

But the reactor in terms of concept, the graphite moderator, is indeed——

Senator JOHNSTON. But it does not have containment.

Mr. MEINHARDT. This reactor does not have containment, nor did the Chernobyl reactor.

N Reactor has what is called a confinement system. If you have a condition where you have a pipe rupture, and you have steam released giving you an initial pulse of energy, a pulse of steam, measured in pounds per square inch. That initial pulse of steam in this particular reactor is vented to the atmosphere, but it is vented in a time period where you don't have radioactive fission products mixed with that steam yet. In other words, that relieves the pressure without releasing fission products. The system then closes down because then you are dealing with a constant pressure. And then everything goes out through filters into the environment. That is the concept of this confinement system.

The concept of a containment system, on the other hand, that initial pulse in typical light water reactors which could contain fission products is contained by that dome.

In the commercial sector, there are several different varieties withstanding different pressures. The newer ones, of course, are much, much stronger than——

Senator JOHNSTON. How about the hydrogen, is that supposed to be as well?

Mr. MEINHARDT. What you want to avoid is a hydrogen concentration on high enough to become an explosive mixture. Most containment systems have some sort of a hydrogen buildup mitigation system.

Now N Reactor has operated over its life under the condition that we do not believe that we can have an explosive mixture of hydrogen pocketed anywhere in this reactor, based on operating parameters defined in the safety analysis report. There are some people that still believe this very strongly. However, we are taking action as a result of the Roddis Panel and others that we want to put in a hydrogen monitoring system to verify that we do not have an explosive mixture. And, believe me, this is only under a severe accident condition that you will have significant quantities of hydrogen.

Senator JOHNSTON. Well, if the hydrogen is vented, how could you have an explosive mixture?

Mr. MEINHARDT. Well, that is the issue with this particular reactor, because you are continually venting through those filters.

And so the issue is, can you ever have, in any one place in the reactor, an explosive concentration of hydrogen? And so that is really one of the issues that we are trying to address right now in terms of what type of hydrogen mitigation system that we should have.

For example, one of the ways you would get away from a hydrogen buildup like that in a commercial reactor is you just have a continuous ignition. You have an ignitor in there that continuously burns the hydrogen and never lets it reach a point where you could have an explosive mixture.

Well with a system like this, and the fact that you are continually venting in there, you know, how would you ever get that to ignite?

The other issue is if it ever could be ignited condition, would that pressure be more than what some of the seals in the reactor could withstand? And so there is a very, very concentrated effort ongoing to try to analyze exactly what is the proper thing to do with respect to hydrogen mitigation in this reactor.

Now the confinement zone we are talking about, by the way, is really represented by this whole enclosure [indicating], even in the steam generator area. As you know, in N Reactor, we simply generate steam and then that steam comes over here, and this represents the power station operated by the Washington public power supply system.

SAVANNAH RIVER REACTORS

I would like to talk for just a second or two about the Savannah River reactors. We have had an issue raised with respect to the operating level of those reactors. We are now at about a 50- to 60-percent power level, depending upon what the fuel charge is. You can operate a tritium charge at a little bit higher power than you can a plutonium charge.

Senator JOHNSTON. You are going to have to replace this core soon, aren't you?

Mr. MEINHARDT. Sir, the N Reactor core is going to have to be—that reactor is going to have to be shut down. What you get through time is growth of the graphite. And we can track that. We have a very extensive monitoring program going on.

We anticipate that in about, certainly by 1995, and perhaps before that, that graphite would have grown to the point that it is touching the bottom of the top shield in the reactor, requiring extensive rehabilitation to continue operation. And when that occurs, the reactor will be shut down forever.

The remaining operating life of this reactor is probably on the order of 7 years. That's all it has left in it.

Now on the Savannah River reactors we have got two problems to deal with that were recently raised partly by the National Academy, but mostly because of some of the internal work done by the contractor. In an accident condition where you had a major loss of coolant—that is, a worst case loss of coolant type of accident—you would have two transient conditions where there is some question about whether or not the emergency core cooling system [ECS] can deal with it.

The worst case accident consists if you had a double-ended pipe break, and simultaneously with that, you had a second failure—there are three failures, by the way—you had a second failure of a valve that would not open, and a third failure in the pipe break occurs in a pipe containing an ECS.

We know that we can make changes to overpower the low flow condition by a couple of different means, enough to take care of the loss of coolant in the latter part of the transient. But there was an issue raised with respect to the initial transient and it had to do with whether or not in one of these fuel rods—keeping in mind the water passes through each of these channels in the fuel rod—whether or not you would maintain continuous flow into all these channels at about the 3 to 5 second point of a loss of coolant accident. For that reason, because of some uncertainty, what we are doing is operating the reactor at a power level, such that we absolutely can preclude the bulk boiling or steam formation within these tubes under an accident condition. Until such time as we can model this thing, do some experimentation, and then we should be able to come back up to some reasonable power level and it may very well be 100 percent, exactly where we were before.

But the inadequacy that was discovered was basically one of not having done adequate experiments back in the 1970–72 timeframe. And we are going back and setting up those experiments on somewhat of a crash basis so that we can, indeed, prove that these are three reactors that are safe to operate continuously at power levels that we had operated at previously.

I also want to say one more thing with respect to this double-ended pipe break. What we are talking about are accidents that typically have probabilities as low as in the 10^{-10}. A commercial power reactor operates at a probability of core damage of about 10^{-5}. In fact, there are certain commercial reactors out there today, the earlier ones that are operating at a core damage probability of 10^{-4}. The Savannah River reactors have a probability of a core melt accident of about 10^{-5}.

This is a loss of coolant accident which has a probability of roughly 10^{-6}. So we are really talking about a very, very remote possibility of having these kind of accidents, plus the fact that it is based on the premise that you would have at one of the inlets have a double-ended simultaneous guillotine-like pipe failure, which means you would be running water out of the reactor, and your emergency core coolant water in that system would be running out also.

Title 10 of Code of Federal Regulations, Part 50, Appendix A, of the NRC standards, which is just in the process of being updated at this time to the possibility that you cannot have this kind of double-ended pipe break, even though that is what we were planning against.

Now, in fact, we should be able to prove that absolutely that kind of thing doesn't happen, cannot happen. Then what we have to do is, dream up another worst case, which probably cannot be as bad as this kind of accident condition, and then plan our tech specs and our operating parameters and putting those through findings the process of evaluation.

We really believe our reactors are quite safe. There is an issue, though, with those reactors as they were built in the early 1950's. We have not discovered any life-limiting mechanisms with respect to the Savannah River reactors, or at least these three that we are now operating, but they are old. They are literally older than some of the people in this room. It is unfortunate they were all built in the same timeframe.

You know, I would like to be able to tell you that one of them is 5 years old, one of them is 10, and one is 15, but that is not the case. They are all pretty old reactors.

And so we have a very, very aggressive monitoring program to assure ourselves that if there is going to be something wrong with them, we know what it is and when it will happen so that we can take the proper action and replace those vital assets to maintain the security of the United States.

Senator McClure. How long will it take you to make that determination, to run those new tests on Savannah River?

Mr. Meinhardt. On the Savannah River reactors?

Senator McClure. Yes.

Mr. Meinhardt. We have a couple of different time periods we are looking at. We have a 90-day period in which we think we are going to have an initial answer. We gave ourselves 90 days to get that answer.

It may be that that will give us a sufficient answer to raise power somewhat. To prove a 100-percent case, that may take us a little bit longer.

Senator McClure. How much?

Mr. Meinhardt. It depends upon the amount of experimentation you need.

Senator McClure. What kind of ballpark are we talking about?

Mr. Meinhardt. Oh, 6 months, something like that.

Senator McClure. All right; 90 days and 6 months.

Mr. Meinhardt. But our first—you know, the first pressure point, we have set for ourselves is to determine what we can prove within 90 days. That is, that we are operating either now at the right power level or, more importantly, that we think we can go up to about the 75-percent level.

Mr. Foley. Let me point out, John, too, that as part and parcel of this whole process we have involved the National Academy of Science now also. So when we say our computations will be done, we have to process this through the National Academy of Sciences and that may take us a little bit longer to bring them all on board. But we are doing it in full concert with them.

Senator McClure. Those supply charts that you had assume Savannah River at full operation?

Mr. Meinhardt. No, sir; they do after a point, but they have taken into consideration the fact that we are operating at 50 percent here for a while.

Senator McClure. Well, you didn't know that in January when the other charts were drawn.

Mr. Meinhardt. Yes; you are right.

Senator McClure. And you didn't make any change in the March 30 reports. Now there is something missing in that.

Mr. Meinhardt. You are talking about the width of a line.

Senator McClure. All right.

IMPACT ON MATERIAL PRODUCTION

Mr. MEINHARDT. It is relatively minor.

I do want to point out something that is very important. You know, we started out this conversation about the importance of tritium in the stockpile, and the fact that two reactors were operating on tritium down there now. But they are operating now at a 50-percent level, or approximately. [Deleted.]

Now we are going to have to work with the DOD to find out if that will impact any of the weapons [deleted].

Senator MCCLURE. [Deleted.]

Mr. MEINHARDT. [Deleted.] The logistics chain. It is a big system.

Senator JOHNSTON. What would it impact on? Anything?

Mr. MEINHARDT. We are trying to avoid any impacts on weapons. That is the first thing.

One of the first things it impacted, by the way, was—I'm happy to report to you that it is no longer the case—we sell, from that inventory, tritium in the commercial market for use in medical research and in making emergency lights. For example, on many of the airliners you fly on you will have a set of lights that remain on all the time. That is a tritium-powered light. It is done because tritium will activate phosphoreus and will remain on essentially forever or until somebody breaks it and releases the tritium gas or it decays.

This is a relatively small market. There is a very important market for medical research and other things. And we typically sell 200 to 300 grams per year. You immediately get the question, whether or not you let that tritium supply [deleted]. And, of course, we have obviously decided to continue to sell tritium to the commercial and civilian interests. This may cause some delivery slip or something, but it is not going to, in the aggregate, I think, affect the war fighting potential of the United States that greatly. But it does cause you to think.

There are people depending upon tritium other than the weapons program, and this is the only source. The fact of the matter is that you have a choice. The French don't sell it. The Canadians will be selling it sometime in the future, probably in the next year. The British don't have it for sale. And it turns out the Soviets do.

INSENSITIVE HIGH EXPLOSIVES

Senator JOHNSTON. Well, I hope you will proceed with speed to replace the bombs on the B-52's with the insensitive high explosive material.

Mark, I don't think you were here the other day, but those thermonuclear bombs can actually, if you had a fire on board, it could activate the sensitive high explosive, not insensitive. And while it would not be a nuclear explosion, it could spread plutonium over an area larger than that detected by Chernobyl. It could be a worse accident.

And they had a picture of a fire on a B-52. Just luckily the wind was blowing in the other direction, so the fire didn't reach the weapon. I had no idea this was so. But we are facing a great risk, an avoidable risk. I mean this is a greater risk than you have got at the N Reactor.

Mr. FOLEY. If you get a fire, you are going to have a problem. There is only [deleted] of the total inventory that has the insensitive high explosive.

General FALTER. [Deleted.]

Senator JOHNSTON. They are not subject to the fires?

General FALTER. There are certain models of them that are not; that is correct. There is a grand total of, I believe, eight models of the B–61 at the present time, [deleted].

Senator JOHNSTON. I am really surprised that, over these years we haven't had a fire detonating one of those things on a B–52.

Mr. FOLEY. We have been lucky.

Senator JOHNSTON. Now we had a crash over in Spain, I think.

Mr. FOLEY. Palomares.

Senator JOHNSTON. Yes; we had Palomares, Spain.

Did the HE go off?

Mr. FOLEY. It did in one bomb is what my recollection is. There were three weapons that were involved. One of them dropped in the sea, one was exploded on land, the other one was recovered broken up on land.

Am I correct on that, John? Do you recall?

Mr. MEINHARDT. That's right.

Senator JOHNSTON. Well, the one that blew up, what did it do?

General FALTER. Well, that was the bulk of the scattering. If you recall, we had an enormous cleanup job that was conducted over in Spain, where we scraped the surface of the Earth, and we took the contaminated soil in drums, and that was actually brought back to the United States. It is stored at the present time.

We had a similar event which occurred at Thule, Greenland. It didn't actually occur in Thule, but that is where the party worked on it. That was the closest town to it. It hit a Greenland ice cap in a crash of a B–52. And there was a burning and a scattering of materials in that one. I am not sure whether the bomb truly exploded or whether the materials were scattered and burned. I think it was scattered and burned, and it has got the same effect.

Senator JOHNSTON. How big an area was affected?

General FALTER. Sir, I can get that for the record, but I don't recall off the top of my head. That thing goes back to 1968, I believe.

[The information follows:]

THULE ACCIDENT

The accident at Thule occurred on January 21, 1968, when a B–52 crashed and burned on the ice some 7 miles southwest of the runway at Thule AFB, Greenland, while approaching the base to land. Six of the seven crew members survived. The B–52 carried four nuclear weapons, all of which were destroyed by fire causing some radioactive contamination in the area on the sea ice. Cleanup operations commenced over the next 4 months with representatives of the Danish government monitoring. Although an unknown amount of contamination was dispersed by the crash and ensuing fire, some 237,000 cubic feet of contaminated ice, snow, and water, including the crash debris, were removed to a storage site in the United States.

The cleanup operation consisted primarily of scraping and removing the snow, ice, and water from an area of approximately 60,000 square meters (15 acres). This mixture was placed in large storage tanks where it was melted and then placed into smaller containers for shipment to the United States. After completing this operation, an area of about 30 square miles (20,000 acres) was reexamined using radiation detection equipment and verified that no radiation hazard existed.

Senator JOHNSTON. How about the Spanish accident?

General FALTER. Sir, we will get the same information. But it was quite a large area. We are not talking 3 acres or 5 acres. We are talking multiple tens.

Senator JOHNSTON. Multiple tens of acres?

General FALTER. Tens of acres; yes, sir.

[The information follows:]

PALOMARES ACCIDENT

The accident at Palomares, Spain, occurred on January 17, 1966, when a B–52 and KC–135 collided during routine air refueling operations. Both aircraft crashed near Palomares with only 4 of the 11 crew members surviving. The B–52 carried four nuclear weapons which were separated from the aircraft in the air. Two of the weapons were destroyed when their high explosive materials exploded on impact with the ground; the other two were recovered intact. The two that exploded dispersed radioactive material, contaminating the nearby soil and vegetation. Cleanup operations were conducted by U.S. personnel with representatives of the Spanish government monitoring, and approximately 1,400 tons (41,000 cubic feet) slightly contaminated debris were removed to the United States for storage.

This cleanup operation consisted of scraping 23,000 square meters (5 acres) of soil and vegetation, burning the vegetation and plowing the soil over an area of 170,000 square meters (42 acres), and just plowing an area of 2.07 million square meters (511 acres). This operation effectively insured that any radiological hazard was eliminated. This area is monitored annually under a Department of Energy program.

Senator JOHNSTON. Not tens of square miles?

General FALTER. No, sir; nothing like that.

Mr. MEINHARDT. If I could interject, and I am just remembering this from photographs, aerial photographs I was involved with at the time in the Thule thing, that the scattering, or at least the area that was kind of marked off around the exclusion area was really only equivalent in that case of maybe a dozen B–52's. It wasn't huge, at least the exclusion area.

COMPARISON OF ACCIDENTS

Senator JOHNSTON. It could be an accident worse than Chernobyl.

Mr. MEINHARDT. Oh, certainly.

General FALTER. It could be; yes.

Senator JOHNSTON. And what would make the accident worse than Chernobyl?

General FALTER. I think it would be the spreading and continued burning of the materials.

Senator MCCLURE. With airborne.

General FALTER. Airborne particles. Just burn it up and consume it.

Mr. MEINHARDT. There's aerial dispersal of the plutonium through the burning process. And, of course, the possibility of breathing plutonium.

Senator JOHNSTON. How would the burning process occur? I mean if you have an explosion.

Mr. MEINHARDT. Fed by aircraft fuel, or whatever.

Senator JOHNSTON. That would involve not an explosion really. Just stay on board and burn.

Mr. FOLEY. The high explosive will go off.

Mr. MEINHARDT. And that ruptures.

Mr. FOLEY. And that ruptures.

Senator JOHNSTON. That ruptures it.

Mr. FOLEY. And blows it. And your fuel in the aircraft, the rest is going to go also. I have to ask them, where is the location of the accident? Is it proximate to a major city? Or did the accident occur in a major city, like the aircraft years ago hit the Empire State Building? And you can postulate all kinds of terrible accidents. As for the issue of getting on with these safety fixes, we always welcome it. Currently in the stockpile community it is an absolute imperative.

Senator JOHNSTON. Further questions?

NUCLEAR WEAPONS PROJECTIONS

Senator HATFIELD. Yes, Mr. Chairman.

I would like to go back to the point you made about whether you had convinced us that you needed this production.

First of all, in the memorandum on nuclear weapons projections, say over the last 6 years, has the record of that memorandum, upon which you base your testimony, I assume, has that been overstated or understated? And if overstated, by how much?

Mr. MEINHARDT. I will answer that in two ways, and let me be very direct with your question.

First, if you look at nuclear weapons stockpile memoranda of 1986 and before, you will find on a statistical basis, if you take a 10-year average time period, you will find that the need for plutonium has been overstated [deleted] approximately, and the need for tritium about [deleted].

But now let me talk about the tritium first because, that is a pretty big difference. [Deleted.]

Also, there was some tritium projected but not defined, perhaps for an ABM system that if the Soviets broke out, that you would have to have that amount of tritium.

So that is the reason for what, really, you have to consider to be a gross overstatement.

Now having said that—I haven't spent my life in this business, but I have been fairly involved over the last 10 years or so as a director of weapons production, and now over on the nuclear materials side—I will say, and I think with very good reason, that this is the most realistic stockpile paper that I have seen in that 10-year period. [Deleted.]

I think General Falter, perhaps not to my personal benefit, will say that DOE has forced a more realistic look at that stockpile requirement statement, and I think that is largely because of the leadership of Admiral Foley. Because I think he understands the DOD requirements perhaps better than many of us in the DOE, having served with distinction in the military. There is also the additional pressure, if you will so call it, with respect to the Nuclear Weapons Council that is now in place, an operating function requested by the Armed Services Committees, particularly in the Senate.

So there is a very senior level review process going on with respect to these requirement statements, I think, at an appropriate level and, perhaps, in more detail than ever before.

It is a realistic stockpile paper, I think, this year. You will not find overstatements of requirements, I don't think, in this stockpile paper at all.

Senator HATFIELD. For 1987–88.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. Since 1987 on.

Mr. MEINHARDT. For 1987 on in this 10-year period.

Senator HATFIELD. Since Admiral Foley has come, the track record has improved considerably.

Mr. MEINHARDT. Well, we will have to see where the track record ends up. [Laughter.]

I think the statement is more accurate.

Mr. FOLEY. Let me just make a comment, if I may, because it is all nice with a pat on the back, but I think in the interim process of working this out; in the past, if your budget didn't take care of it this year or perhaps the following year, then we would bow wave. We said, well, in 4 or 5 years we will get well out there. And that time never came.

But in your projections, you had to include that. So we have said, in terms of realism, don't bother to worry about the numbers that you know you can't produce out there in those years. We have a finite limit, even with a surge on it, about how many we can produce. So don't tell me that you have got a requirement that we are going to produce [deleted] weapons if you know we can only put out [deleted]. So it had some nonconcurrences, some arguments, discussions back and forth. And I think we can say——

General FALTER. We never argue.

Admiral FOLEY [continuing]. We are in agreement that this is realism.

Senator HATFIELD. But, Admiral, you will have to agree though that the track record is not all that good——

Mr. FOLEY. I don't know what the track record is.

STOCKPILE REQUIREMENTS

Senator HATFIELD [continuing]. Up until 1986.

Now let me start from the very basic, from my layman's understanding. What do we have today in the stockpile as far as plutonium. [Deleted.]

Mr. MEINHARDT. [Deleted.]

Senator HATFIELD. Does that include plutonium scrap?

Mr. MEINHARDT. That includes the scrap.

Senator HATFIELD. That does?

Mr. MEINHARDT. Yes, sir.

Senator Hatfield. Now that is about what, [deleted]. That extrapolates from about [deleted].

Mr. Meinhardt. Well, let's define what "scrap" is because I think there's been a lot of confusion in the past, there were comments that we had [deleted] of scrap. All you had to do is process that scrap and you could shut down all the reactors today. And that's more than you need. But that scrap has a lot of different degrees of accessibility or ease of accessibility.

The first statement I will make is there is about 3 to 4 metric tons of scrap material that is very, very hard to ever recover. Now we maintain it as scrap because it still turns out to be something that we hope to economically recover at some point. But it is, for example, plutonium that is embedded in the ceramic crucibles that we use in the furnaces when we melt this plutonium. In other words, it embeds itself in literally the sand or slag of the crucibles. It is going to be very difficult to leach that out and purify it to make it usable again in the system. So you have got that amount.

Now normally in a given year you process about [deleted] metric tons of scrap just within the Rocky Flats boundary. In other words, it is material that; for example, machine turnings. You take it back through, and in that process you get some material back quickly, but also part of that scrap has been created into this hard-to-access category.

There is another set of material that we supposedly own—and somebody believes it is readily usable, but it is not—and that is the material that we have lent to the R&D programs. For example, that material in FFTF. That is not weapons usable material at the present time. And there are about 4 tons over there.

There is also the material out of the ZPPR, or zero power plutonium reactor, about an equal amount of material. And that is about 14 percent Pu^{240}. That is not weapons usable. It theoretically could be cleaned up when we have the technology in place, and that technology is represented by the SIS program.

We also have oxides that are relatively facile to recover, and we do that.

Also, for a long period of time, some 17 years, N Reactor in Washington was not operating really in the interest of the Defense Establishment in the United States. Rather, it was operating to produce power for the Northwest, meaning that it was on a fuel grade cycle, and that has a Pu^{240} content of about 12 percent. That material is in the basins. We have been working that off and blending it with material that is produced at lesser Pu^{240} content at Savannah River.

Anyway, if you add all these things up, there are [deleted] or so of material. But what I am basically trying to convey to you is that that is not all readily usable material with respect to the weapons program, in fact, to recover some of this requires rather heroic efforts.

Senator Hatfield. Well, out of the [deleted] if I could keep it to a simplified category, I am trying to find basically the total stockpile. No. 2, how much of that is, if the scrap is included in that figure, how much of the scrap that is included is easily recoverable as against that which you indicate is very difficult, [deleted]. Now those are the basic categories I am really trying to find out.

Mr. MEINHARDT. All right.

[Deleted.]

[Deleted.] The requirement has not changed.

Senator HATFIELD. Well I am asking you, though, how much we have? Have you changed the requirement [deleted].

Mr. MEINHARDT. No, sir. [Deleted.]

Senator HATFIELD. Well, the House testimony was that, according to my information, [deleted].

Mr. MEINHARDT. Maybe what you are——

PLUTONIUM DEMAND

Senator HATFIELD. I am trying to find out the basic plutonium demand that we have now at this point.

Mr. MEINHARDT. All right. Maybe what you are referring to is, I think—and I don't know who that was—we have been asked to look at what makes sense with respect to what is a [deleted]. And I think maybe that is what they were referring to, to look at that again to see what——

Senator HATFIELD. Well, all right. That's all right. I don't——

[Chart deleted.]

Mr. MEINHARDT. But this tells you how much we have got, or would have. [Deleted.]

[Chart deleted.]

Mr. MEINHARDT. And then, of course, if you don't operate N Reactor, you are dealing with this line [indicating].

Senator HATFIELD. [Deleted.]

Mr. MEINHARDT. Typically, you have got some which is easily recoverable.

Senator HATFIELD. All right.

I understand, like a while ago, that way you were using the word "old." I am not sure I know of the reference you are speaking when you say "old." When I was your age, I thought I was old. [Laughter.]

[Deleted.] Is that correct?

Mr. MEINHARDT. At one period.

Senator HATFIELD. Basically on that chart. All right.

Now as I understand the production capability at the current time of the reactors that are operational, what is that, [deleted].

Mr. MEINHARDT. A Savannah River reactor when it is operating at 100-percent power, which it is not, is capable of producing [deleted] per year. Now N Reactor, when it is operating at 100-percent power, is capable of [deleted]. However, again, to look at realism versus projections, if you look at N Reactor, historically, you can really only count on it for [deleted].

Senator HATFIELD. All right.

Now, again referring to the House testimony, I understand that in the testimony, in order to maintain the plutonium to meet the warhead production [deleted] would require the operation of the N Reactor at Richland, Wash. Is that correct?

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. [Deleted.]

Mr. MEINHARDT. As you can see, even with operating N, based on current requirements, [deleted].

Senator HATFIELD. Could you give us information for the record [deleted] without the N Reactor at Richland in that [deleted]——

Mr. MEINHARDT. Yes, sir; by year.

Senator HATFIELD [continuing]. Of that chart, not in the surplus area that you reach when you hit [deleted].

Mr. MEINHARDT. I would be pleased to do that.

Senator HATFIELD. And also, just to complete that, could you give us the surplus after [deleted] that you incorporate on that?

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. You are showing an increase there.

Mr. MEINHARDT. Yes, sir.

[The information follows:]

PLUTONIUM SURPLUS

The plutonium surplus in metric tons of plutonium, as shown on the chart dated March 30, 1987, are given below. In reality, the reactors would be operated only at the level necessary [deleted].

	Fiscal year	Metric tons plutonium
	[Deleted]	[Deleted]

N REACTOR

Senator HATFIELD. Mr. Chairman, I don't want to delay here. I have got some questions on the N Reactor I would like to go into, but I have probably taken my 5 minutes or 10 minutes and I would yield to Senator McClure.

Senator MCCLURE. Well I just want to follow through for a moment.

A moment ago you said you expect the N Reactor to have about 7 years of life, max.

Mr. MEINHARDT. Yes. sir.

Senator MCCLURE. So if we are talking about after [deleted] then you are talking about production without N Reactor.

Mr. MEINHARDT. Yes, sir.

Senator MCCLURE. And I think those graphs kind of left the impression of continuing lines.

Mr. MEINHARDT. Keep in mind that that graph is cumulative, and it shows how much total material you will have in inventory at that point. You will also see that there is a diminishment in the requirement. The demand line starts to go downhill at that point in time, and that is basically because of force structures reflected in that—the nuclear weapons stockpile memorandum.

Senator McCLURE. I would assume that we could make a revision in that graph to jump from the top graph—no, it wouldn't either. That would be because it is cumulative.

Mr. MEINHARDT. Cumulative; yes, sir.

Senator McCLURE. So it is only a decline; it is not a sudden drop.

Mr. MEINHARDT. Right.

SAFETY IMPROVEMENTS

Senator HATFIELD. Speaking of the N Reactor, I understand that by July the EIS will not be complete, that only about 50 or 60 percent of the planned safety improvements, which is a small percentage of the total recommendations by the two commissions, which total, I think, close to 130, will be complete; is that correct?

Mr. MEINHARDT. That is correct, sir.

Again, I would like to get back to what those recommendations are. And you are correct, when you do an aggregation you come up with different numbers. There were actually in excess of 200 recommendations. When you do the cross-matching and put them together in a matrix, it is in excess of 120.

But let's get back to fundamentals.

Senator HATFIELD. But the 50 to 60 percent completed is not of the 200.

Mr. MEINHARDT. No, sir.

Senator HATFIELD. It is only of those which were announced by the Secretary. I believe there were two categories.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. There was the category of those which were planned and then the category of those which were a result of the two studies.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. I think that represents what, about $50 million?

Mr. MEINHARDT. A total of $50 million.

Senator HATFIELD. Or whatever. It should be for the record.

Mr. MEINHARDT. All right.

Senator HATFIELD. I think that was around $50 million.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. But I would like to make sure that when I used the term "50 to 60 percent complete," it is of that group, not of the total number of recommendations made by the two commissions.

Mr. FOLEY. I believe there is a little misunderstanding. Of the total recommendations made by the two commissions, I think they come out to about 225. There is some overlap in there. I think we really come out to a total of about 130.

Senator HATFIELD. 130; 50 and 80.

Mr. FOLEY. Yes, sir.

Senator HATFIELD. That is what I extrapolated, of nonrepetitive or nonredundant recommendations.

Mr. FOLEY. Yes, sir.

Senator HATFIELD. That is correct.

Mr. FOLEY. That is my understanding.

Senator HATFIELD. That is mine.

Mr. FOLEY. And I believe that we will have—my understanding was by July we would have now about 82 percent of that.

Senator HATFIELD. Of the 130?

Mr. FOLEY. I thought about 50 to 60 percent of that would be done. And my understanding is that it will be more than that now. But I will get you the exact numbers for the record.

Senator HATFIELD. Would you get that for the record?

Mr. FOLEY. Yes, sir.

Senator HATFIELD. Let's not, you know, hold you to that until you review it, because I would like to have that specific information. It is very important to us.

[The information follows:]

COMPLETION OF RECOMMENDATIONS

There were a total of 228 consolidated recommendations from all parties that reviewed N Reactor (133 DOE reviews and 95 Roddis Panel). Of this number, 80 percent are scheduled to be completed prior to restart of N Reactor in July 1987.

Senator HATFIELD. Now will the $50 million that we appropriated in our committee last year, in the CR, cover all of the planned plus the recommended ones that are being undertaken at the moment?

Mr. MEINHARDT. That is just the 1987 portion where we would be spending $50 million. Of that $50 million, about $32 million of it is routine maintenance. The additive that we are spending is a——

Senator HATFIELD. Where are you getting the money to do all this other——

Mr. MEINHARDT. That is just out of operating money. It is the money that you would have available instead of paying to operate the reactor because——

Senator HATFIELD. Varying by shutdown, standdown time——

Mr. MEINHARDT [continuing]. You save a little bit.

Senator HATFIELD [continuing]. You are transferring that operational cost to the modifications.

Mr. MEINHARDT. Some of the improvements. And then for the capital equipment, you have the capital account. And some of that won't come due for some of the things that we are talking about.

Senator HATFIELD. Would you also give us a figure of how much more money it would require to complete what the projected program is?

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. I assume that they are going to address 130 eventually of these recommendations.

[The information follows:]

SAFETY ENHANCEMENT PROGRAM FUNDING

The Department will expend about $122 million through fiscal year 1989 to complete the N Reactor safety enhancement effort. This effort includes the costs of scheduled safety work as well as accelerated safety enhancements that were recommended by DOE and private consultants to be completed during the 6-month stand-down period. The costs to complete the planned fiscal year 1987 phase of this program is $50 million; however, some portions of the overall effort may be accelerated because of congressional and Department of Defense interest in bringing the N Reactor back into operation as planned. These accelerated efforts would cause the costs for the fiscal year 1987 phase of the program to increase somewhat with a corresponding decrease in fiscal year 1988 and fiscal year 1989.

Senator McCLURE. Could I ask a question in that context?

Senator HATFIELD. Yes, sir.

Senator McCLURE. When you provide that information, can you give it to us in a time line?

Mr. MEINHARDT. By year?

Senator McCLURE. Yes; and the spend-out rate and when you are spending it.

Mr. MEINHARDT. Yes, sir.

[The information follows:]

SPENDOUT OF SAFETY ENHANCEMENT PROGRAM

The currently anticipated spendout rate is as follows: Fiscal year 1987, $50; fiscal year 1988, $27; and fiscal year 1989, $45.

However, the exact funding profile may change as analyses and testing are completed and the detailed scope and timing of the remaining activities are finalized.

Mr. MEINHARDT. I will have to admit to you today, as I said, with respect to the hydrogen mitigation, there is still some uncertainty as to the exact technical path we are going to go down and, therefore, there are differences in costs of those alternatives.

Senator McCLURE. Yes; I understand that. But you are apparently taking both appropriated money and money appropriated for this specific purpose and operating funds. And I think what Senator Hatfield is after is total costs of the safety program and the new mitigation programs.

Mr. MEINHARDT. Yes, sir.

Senator McCLURE. And I would like to have that expressed in a time line as well. Thank you.

NATIONAL ACADEMY OF SCIENCES RECOMMENDATIONS

Senator HATFIELD. Let me introduce one last group, and that is the National Academy of Sciences. As I understand, there was an agreement made with certain House people that any recommendations made by the Academy that would impact the safety and other such factors after July, that there would be an agreement to even cut to lower power levels if necessary to meet those requirements. Is that correct?

Mr. MEINHARDT. That is right, Senator. There are a couple of options with respect to operating N Reactor. Based upon the recommendations and our understanding of the condition of that reactor, we could go back to, say, something like a full power operation. Without, in my judgment, assuming any undue risk, operating much as we were before but with many of the safety enhancements in hand.

The other option we would have is to operate at some reduced power level when we restart in July, and that reduced power level would be a condition to assure ourselves that there would not be enough stored energy in the reactor such that if we did have an accident, we would have a fuel failure.

Senator HATFIELD. But that would be determined on the basis of the Academy's recommendations; is that correct?

Mr. MEINHARDT. It would be determined on the basis of our calculations as reviewed by the Academy. And we have committed to that review by the Academy. And certainly we would not in any case operate that reactor if there was any question about safety.

Mr. FOLEY. I think that is what we should really comment on, just putting it in layman's terms and minds. The National Academy at any time, if they come up with recommendations that say it is unsafe, then this is a safety recommendation which I believe we are going to abide by.

Senator HATFIELD. Were there any other features to that informal agreement that was made over on the House side?

Mr. MEINHARDT. No, sir; I am not aware of any. And I think I was involved in the conversations. We said we are not going to operate it if the national academy finds something that suggests it is unsafe. And also we would like to restart it in July at a reduced power level, that will insure that we would not have fuel damage until that hydrogen mitigation system is installed at any rate.

Senator HATFIELD. Could you also give us a list of those commission recommendations, Roddis and the other, the total 130? Give us the list of those that you plan to implement and those that you will but consider. For instance, the hydrogen mitigation thing is not, according to my understanding of your testimony a while ago, is not necessarily going to be implemented.

Mr. MEINHARDT. It would not be implemented by July.

Senator HATFIELD. No; but that was part of the Roddis report and recommendation, was it not?

Mr. MEINHARDT. Right.

Mr. FOLEY. That was one of them.

Senator HATFIELD. That was one of them.

Mr. MEINHARDT. Yes, sir.

Senator HATFIELD. But when I asked a while ago if you planned to implement ultimately and how much it would cost, all of the 130, I assumed that since you are not planning to implement the hydrogen mitigation as one of them, I want to know how many others are not planned for implementation.

Mr. MEINHARDT. Sir, I did not say that we were not going to implement hydrogen mitigation. What I said is we are not sure what kind of——

Senator HATFIELD. Oh, I am sorry. I am glad to get that. So that is not all of it?

Mr. MEINHARDT. We would not have it in place by July. I mean, that's——

Senator HATFIELD. No.

Mr. MEINHARDT. Because there is technical debate about how one should go about doing it.

Senator HATFIELD. Well, look at all the others. If there are other technical debates or other reasons which you really have kind of on a secondary list that you would not necessarily automatically implement even if you had the appropriations. I would like to break it down in that kind of a category.

Mr. FOLEY. Yes, sir.

[The information follows:]

SAFETY REVIEW COMMITTEE RECOMMENDATIONS

A listing of the 133 recommendations of the safety review committees is provided. Implementation of all the recommendations is planned. The additional 95 recommendations from the Roddis Panel are also included. Each of these will also be implemented.

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SERIAL NO.	Committee/ Item/	Document Section	Recommendations	Discussion	Discussion Con't	Status	Related Items	Orig. Compl Schedule	Accelerated Compl Date	Date Accel?	Issue Manager
31	DES /5.7	2.1.1	A more aggressive and formal system to make use of operating and safety review information from N Reactor and commercial LWRs should be established.	Shortly after joining INPO in 1981, UNC initiated a program to review and disseminate operating information. To upgrade this effort, a dedicated group will be organized in FY87 and procedures will be upgraded to more clearly establish responsibilities	for translating recommendations into action.	working		4Q87	06/30/87	*	Pysel
40	DES /7.4	2.1.1	Use operating experience at N Reactor and the LWR's to evaluate possible precursors to severe accidents. (I.C.3)	See # 31.		working	31	4Q87	06/30/87	*	Pysel
52	DES /7.4	2.1.1	The necessary changes in the control room reported in UNI-2897 should be completed in a timely way and two potential problems should be addressed (I.D.1.)	Recommendations from UNI-2897 identified 28 design changes. All of the design and analyses have been completed and 2 design changes remain to be installed. These design changes will be reviewed in light of review team findings and incorporated in FY87.		working	105	4Q87	07/01/87	*	Pysel
67	DES /9.13.1	2.1.3	DC Switchgear : Additional precaution should be taken to ensure the flammable liquids cannot be used outside the door leading to room which could leak or spill into room 8, especially during reactor operations.	See # 6.		working	6	3Q87	04/30/87		Pysel
82	TSA /AX.5	2.1.2	Update the battery maintenance program to meet current industry practices.	This program is part of the EDS system and is being upgraded to meet IEEE guidelines.		working		3Q87	07/01/87		Pysel

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84	TSA /ER.1	2.1.1	Revise Emergency Planning documentation to clearly define authorities and responsibilities of the shift manager and the designated Emergency Control Center chairman.	UNI-M-2 Vol 1 "Emergency Preparedness Manual" has been changed to clarify assignment of responsibility.		complete		3Q87	11/30/86	n	Pyzel
91	TSA /ER.6-1	2.1.1	Establish alternate evacuation routes from the N Reactor building and support facilities. Clearly mark evacuation routes.	Alternative actions will be stated in N Reactor evacuation procedure.		working		4Q87	07/01/87	n	Pyzel
92	TSA /ER.6-2	2.1.1	Improve the capability to provide immediate aid in life-threatening situations by using trained shift personnel.	The UNC management position will be re-evaluated.		working		4Q87	12/31/87		Pyzel
93	TSA /ER.6-3	2.1.1	Correct deficiencies in the plant annunciating and emergency response warning systems to assure they can be heard in all areas of the plant.	An action plan will be in place by end of 4th quarter FY86 with corrective action (including any necessary equipment changes) by end of 3rd quarter FY87.		working		4Q87	06/15/87	n	Pyzel
94	TSA /ER.6-4	2.1.3	Evaluate the feasibility of replacing the liquid chlorine facilities for treatment of demineralized primary system makeup water with a less hazardous system.	An Engineering Study will be completed and a program (if required) will be established by end of 4th quarter FY87.		working		3Q87	04/30/87		Pyzel
95	TSA /ER.6-5	2.1.1	Improve personnel accountability to assure a time of thirty minutes is met, as required by most commerical nuclear plants.	The PSN Accountability system initiated in FY86 will be completed and become a functioning part of N Reactor Evacuation Program.		complete		4Q87	12/10/86	n	Pyzel

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96	TSA /FR.4	2.1.1	Expand the scope of the annual facility safety review to include an independent audit of Reactor Control Room activities and maintenance of reactor-safety related equipment, with special attention to the competency of control room personnel.	The scope of the annual safety review will be revised/expanded such that the annual facility safety review to be conducted in FY87 will include control room and safety-related maintenance activities.		working		4Q87	06/30/87	*	Pyzel
97	TSA /MA.2-1	2.1.2	Improve the method of ensuring that all plant material deficiencies are promptly identified and are entered into the Work Authorization system.	Operations and maintenance addressed the problem by reviewing the Work Authorization control system for deficiencies and making selected improvements.		complete		4Q87	12/31/86	*	Pyzel
98	TSA /MA.2-2	2.1.2	Reduce the number of fluid system leaks in the plant.	A program to lessen non-primary leaks throughout the plant will be initiated in FY87. Reduction of unnecessary flow in the radioactive drain will reduce the burden on the soil column.		working		4Q87	06/30/87	*	Pyzel
99	TSA /MA.2	2.1.2	Provide a tracking system to facilitate management's ability to measure progress toward achieving objectives cited in the Long Range Plan.	A revised commitment tracking system is being developed with implementation expected in FY87.		working		FY88	09/30/87	*	Pyzel
101	TSA /OP.1	2.1.1	Improve shift supervisor and shift manager log entries to include times for each entry and to include sufficient information on events which are off normal.			working		3Q87	07/01/87		Pyzel
102	TSA /OP.2	2.1.1	Improve controls over operator aids such as drawings, references and sketches to assure that only correct, updated and approved information is used by the operator.	Controls have been developed and formalized into UNI-N-152. Implementation is on schedule.		complete		2Q87	02/28/87		Pyzel

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103	TSA /OP.3	2.1.1	Improve the tag and lockout system to assure the correctness and presence of old tags and also improve the feedback portion of the system which updates the tag logbook when tags are removed.	Full transition to the new computer based L/T system will be completed by end of 3rd quarter FY87 including personnel training.		working		1987	07/01/87		Pysel
107	TSA /PP.3	2.1.2	Evaluate local exhaust ventilation systems to assure compliance with American Conference of Governmental Industrial Hygenists Ventilation Manual.	At the request of UNC, HEHF conducted an evaluation of local exhaust ventilation systems in UNC facilities during 1986.		complete		1987	11/30/86	x	Pysel
109	TSA /QA.12	2.1.2	Establish and implement a control system to assure that tools, gauges, instruments, and other measuring or test devices are identified, controlled, calibrated, and adjusted at specific frequencies to assure necessary accuracies are maintained to verify..	Inventories of portable measuring and test equipment and bench measuring and test equipment are complete. Instruments in priority locations in the 105N and 109N Buildings have been inventoried for entry in the existing calibration control and recall	systems.	working		FY90	06/30/87	x	Pysel
110	TSA /QA.13	2.1.3	Improve storage, segregation, and marking of chemicals, reagents, lubricants, solvents, and other flammable materials in accordance with the requirements of ANSI/ASME NQA-1 and UNC QA Requirement 13-3.3.			complete		FY88	02/28/87	x	Pysel
118	TSA /OP.11-1	2.1.2	Clean up control zones. Clearly mark and/or identify and neatly store necessary tools, instruments and equipment.	Operations and maintenance are developing plans to improve radiation zone control and housekeeping.		working		FY89	03/31/87	x	Pysel

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119	TSA /RP.11-2	2.1.2	Develop and implement the philosophy and practice of cleaning up the source of uncontained contamination and/or design facilities with the objective of containing contamination at the source.	Plan being developed. Temporary measures implemented Aug 1,1986.		working		FY89	03/31/87	x	Pyzel
120	TSA /RP.12	2.1.2	Improve efforts to reduce exposure through the ALARA program for 1)total plant personnel, 2)the average individual, and 3)work groups, and establish specific measurable goals in each of these areas to consistently reduce doses.	Specific changes to the ALARA program have been determined.		working		FY90	06/30/87	x	Pyzel
121	TSA /RP.4	2.1.2	Take the initiative to expand UNC responsibility realignments to provide all radiological protection program features for construction personnel at N Reactor.	JAJ was a DOE contractor, thus obligated to maintain a radiation control program for construction work. Since UNC is responsible for overall radiation control at its facilities, Radiological Engineering is currently investigating methods of improving	the established system to ensure personnel receive the benefits of a high quality protection program while working at UNC controlled facilities.	working		FY88	07/01/87	x	Pyzel
122	TSA /RP.5	2.1.2	Evaluate and work with Pacific Northwest Laboratory and US Testing to assure that critical personnel dosimeter processing and storage facilities (managed by US Testing) are adequately protected from fire loss.	A study of PNL and US testing methods and facilities to assure protection of vital data will be concluded and recommendations made to both contractors.		working		FY86	03/31/87		Pyzel
127	TSA /TS.2	2.1.1	Revise UNI-N-89 SI-6, "Safety and Environmental Engineering Instruction Manual", to clearly state the conditions under which a Production Test or Development Test procedure can or cannot be revised and what approvals are required.	A study has been completed and procedures upgraded as required.		complete	96	1987	01/31/87		Pyzel

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128	TSA /TS.3	2.1.1	Enforce the time limits for Temporary Plant Modifications.	A revised Temporary Change Notice procedure was issued in October 1986.		working	97	1Q87	07/01/87		Pyzel
129	TSA /TS.5-1	2.1.1	Integrate and more efficiently conduct the review process for the review and distribution of offsite "operating experiences" documents.	See # 31.		working	31	4Q87	06/30/87	*	Pyzel
131	TSA /TS.6	2.1.1	Develop a more comprehensive waste generation reduction program including specific goals for hazardous and radioactive components.	Project H-773, N Area Radioactive Solid Waste Handling Facility, is currently funded as a FY87 GPP. A comprehensive waste generation reduction program with specific goals will be implemented.		working		2Q87	07/01/87		Pyzel
132	TSA /TS.8	2.1.1	Provide a more comprehensive validation system for computer codes used for calculating operating limits.	A study will be completed and procedures upgraded as required.		working	96	4Q87	06/30/87	*	Pyzel
145	ROD /R13	2.1.1	The present contractor is a "special" member of INPO. The Department should have this contractor, and his successor, make full use of the overview services of INPO, in the operations, maintenance, training and emergency preparedness field.	Contractor to obtain DOE approval to apply for full membership status.		working	133,31,40,128		06/30/87		Pyzel
140	ROD /R10	2.1.2	The present design, based on the earlier production reactors is very man-rem intensive during the reloading cycle.				128		06/30/87		Pyzel

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157	[illegible] /LT7	2.1.1	INPO reviews of N Reactor operations should be instituted.	See related items.		working	133,31,48,129,165		06/30/87		Pyzel
158	[illegible] /LT9	2.1.1	DOE and Contractor safety responsibilities should be better defined.	A review is underway to assure that safety responsibilities are clearly defined and understood. The review will be completed by 4/1/87 and identified action items will be assigned for prompt completion.		working			04/01/87		Pyzel
162	[illegible] /LS3	2.1.1	Unable to understand the management structure, top to bottom, that envelops the N Reactor, and believe the line of responsibility to be too long and too tenuous.	Significant internal UNC reorganization has been accomplished to address the accelerated work items efficiently and expeditiously. The organizational structure will be reviewed by the new O & E contractor during the transition.		working			07/01/87		Pyzel
164	[illegible] /LS7	2.1.1	It would be worthwhile to ask INPO to conduct an operational review of the N Reactor.			working	165		06/30/87		Pyzel
165	[illegible] /LS10	2.1.1	It is essential that the improvements recommended by fellow consultants be implemented, with full awareness of the fact that too many changes at once can be antithetical to safety. Therefore, the team must provide priority lists for the recommendations.	The accelerated program addresses the priority and scheduling of improvements.		complete			01/07/87		Pyzel
173	[illegible] /T11	2.1.1	DOE should make greater use of external peer review groups to address reactor safety on a continuing basis. The use of external entities such as ACRS and INPO should be pursued.	Pertinent INPO services will be utilized (see related item).		working	49,165		06/30/87		Pyzel

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177	[illegible] /M5	2.1.1	N Reactor is a special participant in INPO. Arrange for an early INPO operational evaluation. Arrange for continuing periodic INPO evaluations with their follow-up benefits.	See related items.		working	145		06/30/87		Pyzel
178	[illegible] /M6	2.1.1	Arrange for an INPO emergency preparedness review.	Reviews will be requested.		working	85,88,145		06/30/87		Pyzel
184	[illegible] /M13	2.1.1	Ensure that there is an effective on-site and off-site review of off-normal events that occur at the N Reactor to ensure that underlying root causes are identified so that corrective measures can be taken.	See related items.		working	96,112,116,133,115		06/30/87		Pyzel
186	[illegible] /M21	2.1.1	There is an apparent sense of complacency at many levels from the DOE staff on down through contractor operations that "it can't happen here" at the N Reactor.	Additional external review and overview services are being requested.			145		12/31/87		Pyzel
197	[illegible] /P9	2.1.1	N Reactor should become an active participant with INPO. Should implement safety management practices established for commercial reactors, and be audited periodically by INPO, and have its training program accredited by Nat'l Academy of Nuclear Training.			working	31,48,129,133		06/30/87		Pyzel
203	[illegible] /P21	2.1.1	Good safety practices subject to independent audit are necessary to avoid complacency, ensure accidents are prevented and mitigated, and to reduce the likelihood that unplanned for accidents will happen.	See related item.		working	96,115,133		06/30/87		Pyzel

2. Hydrogen Detection and Mitigation

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29	DES /5.7	2.2.2	The effect of a hydrogen burn on the stack filters and doors should be studied rigorously for potential failure.	This task will be resolved by the prevention of hydrogen burning. For additional discussion see related item.		working	56	FY88	07/01/87	Y	Franz
56	DES /7.4	2.2.1	Evaluate hydrogen control equipment. Add the best system unless it would increase the overall risk to public by causing fog sprays to be turned off. (II.D.7)	The Engineering Study has been accelerated. Design and installation of monitoring equipment is proceeding.		working		4Q87	12/31/87		Franz
148	ROD /R5	2.2.1	Provide for hydrogen control by inerting Zone One of the confinement system during power operation.	See discussion on related item.		working	56		07/01/87		Franz
149	ROD /R19	2.2.1	"N" reactor does not now have any hydrogen control systems. "N" does not have a hydrogen indicating system...though it has recently recommended that such instrumentation be installed.	See discussion on related item.		working	56		12/31/87		Franz
152	ROD /LT2	2.2.1	Hydrogen igniters should be installed.	See discussion on related item.		working	56		07/01/87		Franz
153	ROD /LT3	2.2.1	It is important to provide the N Reactor with a means of preventing hydrogen explosions or of mitigating their effect to such a degree that the confiner will retain its integrity.	See discussion on related item.		working	56		12/31/87		Franz
166	ROD /T3	2.2.1	Re-evaluate the generation and control of hydrogen under accident conditions. Investigate the methods of prevention of build-up of explosive mixtures and detonation, for example, controlled burning, recombiners, inerting.	See discussion on related item.		working	56		07/01/87		Franz

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179	ROD /P8	2.2.1	Potential hydrogen generation a N Reactor is greater that that at Chernobyl and other commercial reactors. Hydrogen mitigation should be provided. Evaluate hydrogen generation and distribution under various inerting and/or provide igniters.	See discussion on related item.		working	56		07/01/87		Franz
180	ROD /P3	2.2.1	Install a hydrogen-mitigation system for confinement. Calculate the local concentrations of hydrogen in confinement compartments during an accident,include effects of large amounts/rates of release,and the different locations of release to aid in design.	See discussion on related item.		working	56		07/01/87		Franz
202	ROD /P20	2.2.1	Containments and confinements need to be protected against hydrogen explosion or detonation.	See discussion on related item.		working	29,56		07/01/87		Franz
204	ROD /P22	2.2.1	Issues considered are hydrogen explosion, the adequacy of the radioactive removal design, potential danger of storing accident-generated radioactive liquids in the crib, adequacy of information available to train operators in emergency procedures.	See discussion in item 56 for hydrogen issues. The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	56		07/01/87		Franz
206	ROD /P24	2.2.1	Uncertainties in the containment hydrogen issues are unacceptable and should be resolved with highest priority - no reason to wait for PRA completion.	See discussion on related item.		working	56		07/01/87		Franz

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207	ROD /P25	2.2.2	The N Rx confinement could not survive the pressure increase if an appreciable quantity of hydrogen were to explode, deflagrate or detonate. Exhaust filters are especially vulnerable.	See discussion on related item.		working	29		07/01/87		Franz

3. Confinement System Testing & Upgrades

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8	DES /4.2.3	2.3.2	The extent of testing of the confinement system should be increased to provide additional confidence that the system will satisfy its confinement function following a design pressure transient.	Confinement system boundary will be tested at a higher pressure to assure leak-tightness and validity of accident dose rate calculations at the filtered release pressure.		working	8,26,27,47	FY88	07/01/87	n	Schmidt
26	DES /5.7	2.3.2	The entire confinement system should be tested at as high a pressure as feasible and practical.	Confinement system boundary will be tested at a higher pressure to assure leak-tightness and validity of accident dose rate calculations at the filtered release pressure.		working	8,27	FY88	07/01/87	n	Schmidt
27	DES /5.7	2.3.1	Selected components should be tested at design pressure.	This task will focus on the qualification of confinement system penetrations under accident pressure conditions.		working	8,26	FY88	07/01/87	n	Schmidt
38	DES /5.7	2.3.5	The decontamination factor for Hydrogen Iodide of activated charcoal filters should be determined.	Evaluations will be performed in FY87. These will include a literature survey and appropriate tests and analyses.		working		4Q87	07/01/87	n	Schmidt
57	DES /7.4	2.3.6	Prevent contamination outside Zone I by systems in communication with the primary coolant system. (II.B.2 and (III.B.1.1)	A previous study will have updated, expanded and resulting recommendations will be implemented.		working		FY89	07/01/87	n	Schmidt
60	DES /7.4	2.3.3	Protect containment relief valves from blockage from debris. (II.E.4.2)	The engineering study will be completed in March 1987. Cable tray concerns will be corrected in March 1987. Any other resulting recommendations will be scheduled based on their potential consequences at the conclusion of the study.		working	47,25	FY88	04/30/87	n	Schmidt

3. Confinement System Testing & Upgrades

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48	DES /9.13.2	2.3.4	The procedures used to ensure that the confinement pressure sensing block valves are open should be reviewed.	The EHS that calibrates the confinement pressure switches has a deliberate return to normal procedure, including action to lock wire the block valves in the open position. Consideration will be given, during the current review of the adequacy of MCL's	(Mandatory Check Lists for reactor startup), to include a signed verification of block valve position before each reactor startup. The need for additional physical access controls will also be considered.	working		2Q87	07/01/87		Schmidt
174	ROD /T12	2.3.7	N Reactor confinement is designed to provide for controlled releases to the environment under accident conditions. Questions remain as to whether components operate as designed and programmed. Continued surveillance and testing of components is necessary	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values, and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts	and the continued surveillance tests are designed to fulfill this recommendation.	working	8,26,27,etc.		03/31/87		Schmidt
187	ROD /P2	2.3.7	Resolve the uncertainties in performance of the N Reactor confinement system.	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts	and the continued surveillance tests are designed to fulfill this recommendation.	working	8,26,27,47,48		03/31/87		Schmidt
201	ROD /P19	2.3.7	Adequate confinement or containment is needed to protect the public from radioactivity released in a serious accident.	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts and	the continued surveillance tests are designed to fulfill this recommendation.	working	187		03/31/87		Schmidt

4. PT, Graphite & Surveillance

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1	DES /4.2.3	2.4.1	A program to understand the "leak-before-break" characteristics of the carbon steel primary coolant system piping should be undertaken.	Leak-before-break is an important issue for LWR's built with stainless steel piping. N Reactor's piping is carbon steel, which does not have the same problems with stress corrosion cracking as stainless steel. The primary piping is inspected for leaks	during a primary hydro prior to each startup, about every five weeks. Selected thickness measurements will be made on the carbon steel piping.	working		FY88	06/30/87	n	Galioto
35	DES /6.1.1.4	2.4.2	The pressure tube rupture analysis (3) should be improved as discussed in 6.1.1.3.	Detailed seismic and thermal hydraulic analysis of the reactor core was performed in 1985 which demonstrated that seismic events or pressure tube ruptures would not result in propagating failures or prevent safety systems in performing design functions.	Additional studies were implemented in June 1986 to study pressure tube axial splits and reflood transients.	complete	36	3Q87	12/30/86	n	Galioto
36	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : sensitive NDE inspections be performed of a minimum of 50, and preferably 100,pressure tubes per year.	Current plans for sensitive NDE are for initial inspections of a limited number of tubes in 1987 to qualify the inspection equipment. Annual inspections of fifty or more tubes will be planned, starting in FY87 with an annual reassessment of the number	planned for subsequent years. Numbers of inspections will depend upon results of prior inspections and inspection program requirements. FY87 inspections to be performed by 6/30/87 will not involve detailed evaluation of results.	working		4Q87	07/01/87	n	Galioto
37	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : at least 2 tubes be removed and metallurgically examined per year.	Two tubes were removed for examination in 1984. Testing and evaluation of these have been completed. Four tubes will be removed in FY87 and preliminary examinations of prime cut sections completed by the fourth quarter. Two tubes a year will be removed	after FY87.	working	36	4Q87	07/01/87	n	Galioto

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38	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include ;tests to determine whether there are any effects of high hydrogen and creep on defect growth in irradiated material...	Tests have been conducted to determine the effects of defects and hydrogen. Additional tubes are planned for removal and examination as noted in # 37. Tests will be performed to determine the effects of defects in irradiated material with hydrogen well	above current levels.The effects of Hydrogen on defect growth rate will be studied using archive material. Initial results will be available in FY87. Plans for NDE of reactor tubes will include tests for evidence of these effects.	working	36	4Q87	03/31/88		Galioto
39	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : burst tests with tube material removed from the inlet, middle, and outlet regions of pressure tubes.	Burst tests were conducted in 1978. Burst testing will resume in FY87 as a standard part of testing tubes removed for examination. These tests will be conducted on material from tubes that have been removed for examination.		working	36	4Q87	05/31/88		Galioto
40	DES /6.1.1.4	2.4.2	In the event that the surveillance program indicates that a substantial margin against tube ruptures cannot be firmly substantiated, plans for replacing the current pressure tubes should be accelerated.	Current plans and design activities support pressure tube manufacturing with the first set of qualified tubes available at the end of CY88. Acceleration of this activity will gain 8 to 10 months; however, the additional schedule acceleration represents	an operability, not a nuclear safety issue, and hence was accorded a relatively low priority. The acceleration is not currently planned.	working		FY89	07/01/87	*	Galioto
41	DES /6.1.1.4	2.4.2	The effects of possible graphite cooling tube water impinging on an embrittled pressure tube should be analyzed.	Operating procedures and requirements provide that the reactor be shutdown upon confirmed leakage within the graphite moderator. Leak detection methods include monitoring of water collection rates from the dryers, gas system dew points, and flow	monitoring of all cooling tubes withing the moderator. An evaluation was performed to determine the magnitude and potential consequences of a local cold spot caused by water from a GCS tube impinging on the outer circumference of a pressure tube.	complete	36	1Q87	02/28/87		Galioto

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42	DES /6.1.1.4	2.4.2	Tests be performed to assure that pressure tubes cannot be failed by local graphite offsets of the type described in Section 6.1.2 below.	See # 43.		working	36	4Q87	04/13/87	*	Galioto
43	DES /6.1.2.2	2.4.2	The possible pressure tube strains and stresses resulting from credible graphite block offsets should be quantified and compared to failure strains.	The effects of gradual graphite distortion have been studied as has dynamic displacement of graphite caused by postulated tube rupture and earthquake loads. The effect of localized graphite block displacements (offsets) will be quantified by analysis by	the third quarter of FY87. The resulting report will indicate necessary follow-on actions including tests as described in # 42.	working	36	4Q87	04/30/87	*	Galioto
44	DES /6.1.2.2	2.4.2	Tests of blocks and/or tubes should be performed if necessary to obtain reliable values.	Activity must await completion of # 42 & 43.		working	36,42,43	4Q87,	12/31/87		Galioto
45	DES /6.1.2.2	2.4.2	Methods should be developed to monitor stack distortions that are possible precursors to sudden offsets.	Activity must await completion of # 42 & 43.		working	36,42,43	4Q87	10/30/87		Galioto
65	DES /8.7	2.4.2	The severe accident which would be initiated by a propagating failure of pressure tubes and its impact on graphite stack disruption with respect to capability to shut down reactor power operation, should be analyzed on a best-estimate basis.	Single pressure tube breaks were analyzed in 1985 and demonstrated that tube failures would not propagate. Recent analysis for both circumferential and longitudinal breaks with more current analysis tools has reconfirmed the previous analysis. Thus it is	concluded that propagating tube ruptures is not a credible event.	complete	64	4Q87	12/30/86	*	Galioto
134	/	2.4.3	Install in-core neutron detectors.	Completion of construction is planned in FY87.		working			06/30/87		Galioto

5. Reactor Effluent Control

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3	DES /4.2.3	2.5.1	Efforts to reduce primary coolant system leakage should be vigorously pursued.	System leakage has been reduced by the repair and replacement of several valves during the Valve Program. This effort will continue in FY87. An environmental upgrade program will continue efforts to reduce leakage. Also, efforts towards removal of	old, unneeded primary boundary valves will continue. Three of six sub-items have been accelerated by two years. Reduction of primary coolant leakage will reduce the radionuclides released to the environment.	working		FY88	07/01/87	x	Blankenship
63	DES /8.6.3	2.5.5	It is recommended that the desirability of treating crib water with sodium hydroxide to limit iodine re-evolution should be evaluated.	An evaluation is being performed. Based on results, a plant modification and procedure changes may be required as part of a new program.		working	66	FY88	05/31/87	x	Blankenship
81	TSA /AE.1	2.5.2	Provide facilities to enable rapid detection of a leak from the liquid waste collection tank (1310-N Tank) and from the associated inlet and outlet lines which are underground.	A level detector has been installed. Preliminary design for test wells to monitor leakage is underway. Reliable tank inventory monitoring provides for early detection of any leaks of N Reactor decontamination waste.		working		FY89	05/15/87	x	Blankenship
159	RDD /LT10	2.5.4	Coolant bleed-off discharge to the ground should be discontinued.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	3		07/01/87		Blankenship
160	RDD /LT11	2.5.4	An alternate plan for handling accident waste water is needed.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working			07/01/87		Blankenship
181	RDD /M10	2.5.3	Stop primary coolant discharge to the surrounding soil. An ion exchange system is needed to purify primary coolant. In the event of a severe accident, a method to contain the waste water until it can be decontaminated is needed.	99% of the 100N off-site dose is due to Sr90. The major source is from exposed fuel in the 105N basin. Fuel damage arrestor and cleanup of the fuel basin will reduce the Sr90 source.		working	160		07/01/87		Blankenship

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109	ROD /P4	2.5.4	Install a confined basin or tank to contain highly radioactive liquids that will be pumped from the confinement during an accident.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	160		07/01/87		Blankenship
215	ROD /P34	2.5.4	Installation of a closed vessel or tank to contain the radioactive liquid pumped to the crib is recommended. Similar consideration should be given to the liquids that are normally bleed and leak from the primary coolant system.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.			160		07/01/87		Blankenship
223	ROD /P38	2.5.4	N Rx does not operate within the risk level concluded in the 1978 safety study because of risk of contamination ground and surface water from radioactive liquids produced in a severe accident and pumped to a crib outside the confinement.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system. PRA will resolve.			160		07/01/87		Blankenship

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135	/	2.4.3	Implement flux-flattening operation.	60% of flux-flattening changes to be installed in FY87.		working		FY91	06/30/87		Galiato
136	/	2.4.3	Perform graphite surveillance analysis and modeling.	Will provide updated analysis of graphite to project future trends and distortion conditions. Additional pile motion monitors to be installed		working		FY91	07/01/87		Galiato
137	/	2.4.3	Analyze graphite distortion consequences.	Will provide updated analysis of graphite to project future trends and distortion conditions. Additional pile motion monitors to be installed.		working		FY91	07/01/87		Galiato
139	NRB /R4	2.4.2	Study the possible effects of a longitudinal split type break in an embrittled Zirconium alloy process tube within the graphite and the stresses on adjacent tubes which could propagate in the core and result in a Chernobyl-like accident.	Detailed seismic and thermal hydraulic analysis of the reactor core was performed in 1985 which demonstrated that seismic events or pressure tube ruptures would not result in propagating failures or prevent safety systems in performing design functions.	Additional studies were implemented in June 1986 to study pressure tube axial splits and reflood transients.	complete	35		12/30/86		Galiato
147	NRB /R17	2.4.3	Graphite growth in the stack is beginning to reverse from a long period of growth (approaching maximum of 2 inches by about 1989-1990).	Enhanced surveillance and analysis underway and will continue.		working	137,138		07/01/87		Galiato
155	NRB /L15	2.4.2	Intensification of process tube monitoring is endorsed.	See related items.			36,37		07/01/87		Galiato
172	NRB /F9	2.4	Maintain a vigorous surveillance and replacement program, especially with regard to process tube failure and graphite growth.			working	36,37,136,137		07/01/87		Galiato

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105	NRD /R14	2.4	Expand surveillance and monitoring of the N Reactor to refine the estimate of date of end of normal life. In addition to zircalloy-2 tube embrittlement and graphite growth, include selected valves, systems, and components.	This is a very broad effort, and encompasses ongoing activities in pressure tube and graphite surveillance/ PIE, the ISI program efforts, and Equipment Qualification efforts. Inspection and tests required by the ASME code will be among the accelerated	activities.	working	36-40,42-45,136,137,27,47		06/30/87		Ballato

6. Accident Analysis / Risk Assessment

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6	NES /4.2.3	2.6.3	The probabilistic risk assessment programs that are currently envisioned should be upgraded to level 3.	UNC's Safety and Reliability Evaluation Program is being accelerated and expanded to provide the Level 1 analysis required to support completion of a full-scope Level 1 PRA by the end of FY87 (see # 70). Analytical tools essential to the Level 2/3 phases	of the PRA are being developed (see # 71). The FY87 budget request for the Level 2/3 program provides for development of a detailed management and work plan, completion of plant familiarization, and performance of accident progressions analyses.	working		FY88	12/31/88		Shupp
9	NES /4.3.3	2.6.2	Accident analyses should be performed to determine the effect of pressurizing confinement at a time when significant quantities of fission products are present.	The subject analyses will be performed using upgraded analysis tools (see 022) in support of the Level 2 PRA.		working		4Q87	09/30/87		Shupp
16	NES /5.7	2.6.3	A full scope level three PRA should be performed for the N Reactor.	See recommendation # 4 - NES/4.2.3/003.		working	6	FY88	12/31/88	-	Shupp
18	NES /5.7	2.6.2	Xenon instability analyses should be updated and include an analysis of stability against azimuthal xenon oscillation coupled with thermal-hydraulic effects resulting from the semi-independence of cooling of the two halves of the reactor.	Conservative analyses of N-Reactor confirm observations that the core is stable towards Xe or power oscillations. Observation of the process tube outlet temperatures and power range monitors have not indicated a presence of azimuthal Xe oscillations.	This question will be further explored with experimental measurements following the installation of the in-core detector system and analytically using a special three-dimensional core analysis code by the end FY87.	working	-	FY88	04/30/87	*	Shupp
19	NES /5.7	2.6.2	Blockage of pressure tubes by fuel failures should continue to be considered in the evaluation of severe accidents.	The Level 1 PRA analytical support will include evaluation of pressure tube blockage events, including blockage due to fuel failure. This evaluation will be completed in FY87.		working	24	FY88	09/30/87	*	Shupp

6. Accident Analysis / Risk Assessment

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22	NES /5.7	2.6.1	Analytical tools used for thermal hydraulic analyses should be upgraded as appropriate with emphasis on best estimate capability.	The ongoing effort to develop upgraded tools has been accelerated. Codes have been selected for system analysis (RELAPS,TRUMP-BD, SCDAP) confinement system analysis (HECTR,COBRA-NC), and fission product transport (TRAP-MELT, CONTAIN). Model development	will be complete in FY87.	working		3Q87	06/30/87		Knapp
23	NES /5.7	2.6.2	The best estimate capability should be aggressively used to search out the limits of N Reactor performance.	The analytical tools required to address operating and safety limits will be upgraded in FY87 and a full re-evaluation of operating and safety limits will be completed in FY88.		working		FY88	03/31/88		Knapp
28	NES /5.7	2.6.2	A study should be conducted on the possible benefits of operating the confinement systems at sub-atmospheric pressures, once the steam vent valves are closed.	An evaluation will be performed using upgraded analytical tools. The study will support re-evaluation of proposed hydrogen mitigation schemes and the Level 2 PRA.		working		FY88	06/30/87	*	Knapp
33	NES /5.7	2.6.2	The calculation of the flow monitor set points should be evaluated based on best estimate models.	Flow monitor set points have been developed using experimental data for the specific N Reactor tube in tube fuel and pressure tube geometries. This experimental data base is applied to upgrade computer models and a re-evaluation of operating limits will	be completed in FY88.	not started	23	FY88	03/31/88		Knapp
34	NES /5.7	2.6	Formal LOCA analysis in conjunction with selected check valve failures should be conducted using new codes and results of the PRA.	LOCA analysis with check valve failure will be evaluated with upgraded analytical tools (see 022) in support of the Level 1 PRA.		working	64	FY88	09/30/87	*	Knapp

6. Accident Analysis / Risk Assessment

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59	DES /7.4	2.6.2	Confirm present assumptions regarding response to LOCA's caused by small openings in the pressurizer. (II.B.3)	The subject transient will be analyzed with upgraded codes in support of the Level 1 PRA.		working	23	4Q87	06/30/87		Bnapp
61	DES /7.4	2.6.3	Evaluate reliability of decay heat removal methods. (II.E.1.1)			working	78	4Q87	09/30/87		Bnapp
62	DES /8.2.3	2.6	The hypothetical accident analyzed in NUSAR appears potentially to be a candidate for assessment in the PRA effort discussed elsewhere. If it is shown to be a risk dominant sequence, it should be re-analyzed, using current source term methodology...	The subject transient will be analyzed with upgraded codes in support of the Level 1 PRA.		working	64	4Q87	09/30/87		Bnapp
64	DES /8.7	2.6.3	Risk-dominant severe accident sequences, determined by the PRA, should be analyzed using current best-estimate models.	Upgraded state-of-the-art, best-estimate codes will be developed for N Reactor analysis (see 822) and used for analysis support of the PRA.		working		FY88	09/30/87	*	Bnapp
66	DES /8.7	2.6.1	Experimental programs should be performed to provide data for analysis. This includes kinetics of dissolution of zircaloy by molten uranium and fission product release from fuel.	Initial efforts in FY87 will be to perform limited evaluations on uranium-zirc alloys, to develop experimental data base requirements, and to perform detailed program planning for FY88 and FY89.		working		FY89	09/30/88	*	Bnapp
69	DES /9.13.3	2.6.3	The undergoing Probabilistic Risk Assessment (PRA) should include common mode failures, including component failures and/or administrative control failure of the safety system bypass switches.	See recommendation # 78 - DOR/V.A3		working	78	4Q87	09/30/87		Bnapp

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78	SGR /V.A3	2.6.3	The Team recommends that the probabilistic risk assessment that has been initiated by UNC-NI be completed as soon as possible. It should be used to verify that challenges to the confinement system have been comprehensively encompassed, and once completed	A detailed task-by-task schedule and cost estimate has been developed to accelerate and expand the Level 1 PRA in response to Recommendations # 69 and # 78. The budget associated with these recommendations includes the incremental costs to advance the	completion of the Level 1 PRA by one year, to expand its scope to include Level 2 integration (see #4), common-mode failure analysis, additional confinement analyses, and internal fire and flood analysis and to provide liaison with the LANL Level 1 PRA.	working		4Q87	09/30/87		Bsapp
79	SGR /V.A3	2.6.1	The Team recommends that computer models of the accidents that form the confinement system design basis continue to be maintained current and be based on current probabilistic risk assessments.	UNC plans to maintain the computer models current - this recommendation does not represent any additional activity or effort. This subject is addressed in much more detail in the later reviews, and therefore we consider it closed.		complete	22	4Q87	01/09/87	*	Bsapp
130	ROD /R1	2.6.3	Radiological consequences of a severe reactor accident at the N Reactor would exceed the dose guidelines now used for licensed commercial reactors.	See related items.		working	4,23,62,64		12/31/88		Bsapp
143	ROD /R9	2.6	...The "N" Reactor design is such that an instantaneous postulated radioactivity release accident cannot be handled during the first pressure venting phase of the accident.	The confinement design is based on fuel failure characterisitics for solid zirc clad metallic fuel without internal gas voids (all fission products are in solution within the metallic fuel matrix) such that no instantaneous release of radioactivity can	occur. This design assumption will be evaluated as part of the Level 1 PRA.		8		09/30/87		Bsapp
144	ROD /R10	2.6.3	The present confinement design has real possibilities of resulting in air releases in case of unexpected accidents even after inerting Zone One.	Confinement behavior for a range of severe accidents will be evaluated with upgraded codes (see #22) in support of the Level 2 PRA.		working	192-195		09/30/87		Bsapp

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146	ROD /R16	2.6.2	...available chemical energy from metal-water reations is significantly greater in "N" and Chernobyl-4 than in TMI-2. Table 1 also shows that the potential hydrogen evolution at the "N" reactor is 20 times that of a TMI-2 and twice that of a Chernobyl-4.	Potential chemical energy conversion from reactor components is controlled by chemical process and rarely is all of the potential energy available in real reaction situations. Codes being developed will consider chemical thermodynamics and kinetics in	the analysis of severe accidents. The amount of zirc metal cladding available for reaction is similar for each reactor system using criteria specified in 10 CFR 50. The zirc cladding mass in N, Chernobyl, and a LWR is 22.7, 33, & 20.2 metric tons respct.	working	56,77,179		06/01/87		Knapp
150	ROD /R20	2.6.3	N reactor meets or exceeds 40 of 55 General Design Criteria established by Appendix A to 10 CFR 50 (NUSAR vol 2). It doesn't meet 6,partially meets 1,and meets the intent of 8. Doesn't meet Appendix K (fission product release) & Appendix R (circuit sep)	The General Design Criteria were developed specifically for standard commercial PWR and BWR Reactors, therefore, are not directly applicable to N Reactor. The application of each design criteria is discussed in detail in the NUSAR. These	specific cases where the consultants questioned the NUSAR analysis are being addressed in the appropriate consultants recommendations, e.g., 140,141,144, etc.	working			12/31/88		Knapp
154	ROD /LT4	2.6.3	Probabilistic risk analysis should be expedited.	See # 78.		complete	4,16,69,78		01/01/87		Knapp
161	ROD /LT12	2.6.3	The consequences of really severe accidents are not included in NUSAR. Such accidents will be a part of the PRA. Those that can be identified now should be examined and analyzed at once without awaiting the completion of the somewhat slow PRA process.	Analysis of degraded core accidents will be initiated when the upgraded computer codes are available (see 022). Preliminary assessment of high frequency core melt sequences will be available at that time from the PRA and will be used as a basis for	evaluation.	working	4,16,69,78		09/30/87		Knapp
163	ROD /LS5	2.6	The N Reactor confinement system should be evaluated in a Level 3 PRA to verify its premise (release of steam and radioactivity would be sufficiently separated in time to allow valves to close after steam release).	See serial # 143 for discussion.		working	4,16,69,78		12/31/88		Knapp

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167	RDB /T4	2.6.3	Expedite and expand the PRA analysis. The contractor should be intimately involved, but because of the magnitude and urgency, it should be assigned to one org who will draw on resources of other groups. Some questions should not wait for PRA results.	See # 70.		complete	6,16,69,70		01/01/87		Gnapp
169	RDB /T6	2.6.2	Re-evaluate the expected chemical forms and quantities of iodine release and the effectiveness of the spray and filter systems in their removal.	Evaluation of expected chemical forms will be accomplished through a thorough survey of literature, possible small scale tests and analysis with upgraded analytical tools (see #22). Evaluation of fog spray effectiveness will be performed with the up-	graded fission product transport codes in support of the Level 2 PRA.	working	22,66,79,etc.		06/01/87		Gnapp
188	RDB /W7	2.6.3	Expedite conduct of a level 3 PRA. Ensure that personnel who will have long-term involvement with the N Reactor participate.	See # 70.		complete	6,16,69,70,163		01/01/87		Gnapp
190	RDB /P5	2.6.2	Update the safety analysis of the chemical form and amounts of fission products that will be evolved from overheated fuel.	See # 169.		working	22,66,79,169		06/01/87		Gnapp
191	RDB /P6	2.6.3	Extend the safety analyses to include accidents that develop higher fuel temps,greater quantities of hydrogen at greater rates, and evolve fission products in different chemical forms, and include accidents involving equipment failure and operator error.	Degraded core accidents more severe than the NUSAR hypothetical accident will be analyzed as part of the Level 2 PRA (see #161).Accidents involving operator errors will be evaluated as part of the Level 1 PRA.		working	22,66,79,36		12/31/88		Gnapp

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192	ADD /P7	2.6.2	Analyze the different chemical and physical forms of radioactivity that can be released to the confinement under accident conditions.	See serial # 169.		working	22,46,79,4,16,69,78,169		06/01/87		Osapp
193	ADD /P7	2.6.2	Analyze a technical basis for the particle-size distribution of particulate radioactivity released to the confinement and transported to other compartments.	The expected particle size distribution will be analyzed with upgraded fission product transport codes (TRAP-MELT, CONTAIN) and application of available data. Sensitivity analyses will be performed with the upgraded codes for assumed particle sizes.		working	192		10/01/87		Osapp
194	ADD /P7	2.6.2	Perform a mass transfer analysis that does not rely on data on radioactivity-removal kinetics obtained when there is simultaneous condensation of steam.	The subject analysis will be performed with the upgraded analytical tools (CONTAIN see 022).			192		09/30/87		Osapp
195	ADD /P7	2.6.1	Study the performance of an analytical technique that has been verified and validate, including verification with data on multicompartment removal systems and validation of assumptions of gas and liquid flow and mass-transfer kinetics.	Upgraded confinement analysis codes which are best-estimate and state-of-the-art will be developed to support the PRA analysis (see 022).		working	22		06/30/87		Osapp
196	ADD /P8	2.6.1	Develop realistic predictions of confinement performance symptoms: time dependent pressure,temp,species, and radioactivity concentrations to be used in training confinement operators and in developing emergency procedures to mitigate confinement malfcns.	The upgraded analytical tools developed for N Reactor (see 022) will provide realistic predictions of confinement behavior. These codes will be used to perform analysis in support of the Level 2 PRA.		working	79,46,etc.		06/30/87		Osapp

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198	[illegible] /P11	2.6.3	The accidents at Chernobyl and TMI show that accidents can happen, from design or operator error or both. Relying on a specified design-basis accident is not sufficient to assure safety. Include operator error and severe core damage in accident analysis.	Operator reliability is an integral part of the Level 1 PRA models. High Frequency events leading to core damage will be completely analyzed in the Level 2 effort.		complete	4,16,69,78		01/01/87		Gsapp
199	[illegible] /P16	2.6.2	Consider the possibility of slugs of water reaching the dry overheated fuel in horizontal channels in accidents involving overheated fuel and metal-water reactions. Also,consider the vertical channels in N Reactor for backup control absorbers.	Reflood of a hot dry core will be studied as part of the severe accident analysis effort.		working	191		09/30/87		Gsapp
200	[illegible] /P18	2.6.3	Accident analysis should include accidents involving operator error and accidents involving severe core damage	See # 198.		complete	4,16,69,78		01/01/87		Gsapp
203	[illegible] /P23	2.6.1	The HUGAR calculations are competently done, but the calculated max temp is close to the threshold temp for autocatalytic zirc-water reaction, thereby questioning the assumption that this hypo accident is suitable for the basis of confinement design.	Reaction kinetics for metal oxidation are governed by well known rate equations and the system heat transfer and heat generation. Complex computer models are used to evaluate these phenomena.		complete	22,66,79		01/01/87		Gsapp
208	[illegible] /P27	2.6.2	There has been no functional test of the ability of the fog sprays to quench steam and remove radioactivity. Assurance of performance rests entirely on the design analysis.	Condensation rates and decontamination factors will be evaluated and documented. See # 214.			8,26,27,168,214		12/31/87		Gsapp

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209	ROD /P28	2.6.2	The only documented design analysis of the N Reactor spray system is that contained in the 1970 safety analysis report.	An updated design and performance report will be prepared.		working	22,44,70,79		12/31/87		Baapp
210	ROD /P29	2.6.2	There are several reasons why N Reactor confinement sprays may not perform in the way predicted by the NUSAR analysis.	Updated analysis using current analytical methods will be conducted.		working	209,4,16,69		12/31/87		Baapp
211	ROD /P30	2.6.2	Elemental iodine is not expected to be present in the reactor during a severe accident as assumed in the safety analysis. Whether hydrogen iodine decomposes to elemental iodine in the confinement and the effect on spray removal has not been analyzed.	Fission product chemistry will be reviewed for postulated severe accidents in N Reactor. PRA studies will evaluate the influence of uncertainty of species on overall risk.		not started	210		12/31/87		Baapp
212	ROD /P31	2.6.2	Information has not been provided to justify the design assumption that the particle size distribution released to the confinement is the same as the particle size used in the spray removal experiment.	A review of aerosol transport, agglomeration, attenuation in the primary system will be re-evaluated.			210		10/01/87		Baapp
213	ROD /P32	2.6.2	The N design analysis seems unrealistic in the calculation of flow of the gas phase from one compartment to another.	These calculations have been revised with current analytical tools and have been found to be correct.		complete			01/01/87		Baapp
214	ROD /P33	2.6.2	It is recommended that the design analysis of the N Reactor fog spray system be reviewed by the group in the DuPont Engineering Service Division at Newark,Delaware.	External competent review of the design bases and decontamination factors used in the analysis will be performed.		not started	210		12/31/87		Baapp

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218	ROD /P37	2.6.3	A full probabilistic risk assessment of the N Rx involving the N safety managers and designers as well as independent outside groups would be preferable to the two parallel assessments now underway.	External review is being performed for the UNC PRA to assure conformance to accepted industry practices. The reviewers represent many facets of industry. UNC staff are integrally part of the PRA efforts.		complete	4,16,69,70		01/01/87		Gnapp
219	ROD /P38	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of technical uncertainty in the production of hydrogen in severe accidents.	This question is being completely reviewed. Updated analytical models are being developed. PRA will guide the analysis and the highest frequency accidents will be completely analyzed.			56,77,146		12/31/88		Gnapp
220	ROD /P38	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of doubt that hydrogen will be so rapidly mixed within the confinement compartments that hydrogen burning cannot occur.	Re-analysis of the hydrogen mixing and transport within the confinement compartments with updated analytical methods has confirmed the validity of the 1978 conclusions.		complete	219		01/01/87		Gnapp
221	ROD /P38	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of the need to install igniters or to inert the confinement to prevent hydrogen explosion.	The 1978 NUHAR technical position on hydrogen mixing in Building 109 has been confirmed in recent studies. Hydrogen concentrations will not reach limits at which burning or explosions are predicted.		complete	219,220		01/01/87		Gnapp
222	ROD /P38	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of technical uncertainties in the design of the confinement fog sprays to remove radioactivity released to the confinement.	Confinement fog spray efficiency will be re-evaluated. Technical bases for the decontamination factors will be supplied.		working	209,218		12/31/87		Gnapp

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224	ROD /P40	2.6.3	The N Rx can be operated within the risk levels found in the 1978 safety analysis report if the uncertainties in that report, as identified herein are resolved.	Revised and expanded analyses will be conducted in support of the PRA.			207,210,218-222		12/31/88		Baupp
226	ROD /L82	2.6.3	It is important for quality control, that the PRA also be subjected to peer review, outside the DOE family.	A competent peer review panel is being formed and will be used to verify the quality of the PRA process.		working			12/31/88		Baupp
227	ROD /P13	2.6	Uncertainties in the predictions of N Reactor confinement now question the level of safety that was concluded in the 1978 Safety Review of N Reactor. N Reactor does not meet some of the tighter safety standards that have evolved after the TMI accident.	PRA to resolve.		working	4,16,23,42		04/01/87		Baupp
228	ROD /R16	2.6.3	The N Reactor is not as safe as our US commercial plants. It should be recognized by the DOE that it does not meet all present-day standards for commercial reactors.	The PRA will quantify relative safety.		working	4,16,23,42,138		12/31/88		Baupp

7. Emergency Core Cooling Systems Upgrades

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12	DES /4.5.6	2.7.2	It is recommended that the concrete block superstructure portions of the 181-N and 182-N Buildings be re-examined for possible wind damage to the walls and the possibility of the blocks falling on vital equipment housed within these facilities.	An Engineering Analysis will be completed in March 1987. Any problems will be identified and an action plan developed for implementation of and corrective action identified.		working		3Q87	03/20/87	*	Kelly
15	DES /4.5.6	2.7.1	The UNC program to provide an alternative source of water for the N-Reactor ECCS should be expedited.	Due to the long lead time required for a true alternate ECCS, a near-term project has been initiated to supplement the ECCS supply until the long-term project is complete. The FDC and engineering study for the Supplemental ECCS were provided to DOE for	approval/information respectively, in Jan 1987. Definitive design has been initiated, but is on-hold pending a system re-evaluation.	on-hold		FY88	/ /		Kelly
21	DES /5.7	2.7.3	Steps should be taken to improve separation between ECCS equipment trains in the 182-N building.	Specific steps to improve isolation of DC controls in the 182N building have been identified and will be implemented in FY87. Design for this task is underway. Also a project to improve fire protection, separation of the 181N and 182N ECCS/Fog Spray	diesels will be completed in FY87.	working		FY89	07/01/87	*	Kelly
24	DES /5.7	2.7.4	An alternate ECCS project should be implemented.	Project B-766, Alternate ECCS Supply, an FY89 Line Item, was initiated prior to Chernobyl. A preliminary rescoping evaluation has been completed and is being documented in an engineering study. Conceptual effects on this project are being accelerated to	permit initiation of definitive design in 1st quarter FY88 subject to DOE funding availability. Accelerated completion date is subject to funding availability.	working		FY92	06/01/89	*	Kelly

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70	DES /9.13.4	2.7.2	Review the seismic adequacy of the suspended ceiling and electrical cabinets in the control room.	See # 12.		working	12	3Q87	03/30/87	x	Kelly
71	DES /9.13.4	2.7.2	Review whether equipment in the vicinity of the 189-N batteries can fall and damage batteries.	See # 12.		working	12	3Q87	03/13/87	x	Kelly
72	DES /9.13.4	2.7.2	Review whether concrete blocks near building 181-N can fall and damage the batteries. Review whether concrete blocks can fall and damage diesel peripherals including fuel lines.	See # 12.		working	12	3Q87	03/20/87	x	Kelly
73	DES /9.13.4	2.7.2	The same recommendation as for building 181-N applies to building 182-N. Also, review the buried fuel tanks and lines. Review the large vertical tanks adjacent to building 182-N for both seismic and wind loading.	See # 12.		working	12	3Q87	04/15/87		Kelly
74	DES /9.13.4	2.7.2	Review the silo near building 182-N for strength and deformation of the pipe connections.	See # 12.		working	12	3Q87	03/30/87	x	Kelly
75	DES /9.13.4	2.7.2	Review portable emergency lighting throughout the plant to ensure that this equipment will not fall from supports during a seismic event.	See # 12.		working	12	3Q87	03/15/87	x	Kelly
83	TSA /AA.7	2.7.2	Evaluate potable water tank and fog spray accum tank for earthquake resistance.	See # 12.		working	12	FY86	04/30/87		Kelly

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141	RRB /RAs	2.7	Providing better physical separation for the redundant emergency water pumping systems and water supplies for the ECCS and the GSCS.	See serial # 15, 21 and 24 for discussion of actions.		on-hold	15,21,24		/ /		Kelly
151	RRB /LT1	2.7	Backup emergency core cooling project should be completed.	See related serial #'s for discussion.		on-hold	15,24,21,182		/ /		Kelly

B. Accelerated Construction

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5	DES /4.2.3	2.8.2	The program to improve habitability aspects of the main control room should be expedited.	Project B-544, Control Room Habitability, is in Definitive Design. Construction is scheduled to start Jan 1987 and to be completed Mar 1988. 60 % completion is estimated by July 1987.		working		FY88	03/31/88		Dugan
17	DES /5.7	2.8.1	The ODCS should be made a safety grade system. It's ability to function in a degraded condition over a long time should be assessed.	An Engineering Study to determine what is needed to make the piping and controls to a safety system and provide an additional water supply and a seismic analysis will be completed by July 1987 and a program will be established. Short-term actions to	upgrade the system will be complete by July 1987.	working		FY89	06/15/88	*	Dugan
85	TSA /EA.2	2.8.4	Provide for operational support during an emergency as outlined in NUREG 0737, Supplement 1 - "Clarification of TMI Action Plan Requirements".			complete	87	FY88	12/18/86	*	Dugan
87	TSA /EA.4-1	2.8.4	Interim upgrade of emergency control center.	The interim 100N Emergency Control Center has been relocated away from 100N.		complete		4Q87	12/15/86	*	Dugan
88	TSA /EA.4-1	2.8.4	Upgrade emergency response capability of the N Reactor control room, emergency control center, and alternate emergency control center. (Does not include # 87)	An engineering study to evaluate options for near-term emergency response facilities upgrades will be complete in April 1987 and upgrades completed by September 1987.		working	87	FY91	09/30/87	*	Dugan
89	TSA /EA.4-2	2.8.3	Install remote shutdown capability at N Reactor for emergency shutdown of the reactor from outside the control room.	Project B-646, Emergency Shutdown Panel, has concluded the Definitive Design Stage and is currently scheduled to finish construction by May 1987.		working		FY88	05/31/87	*	Dugan

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142	ROD /R4b	2.8	Provide protection and separate ventilation for the control room, or an alternate location, during accident conditions.	Provided by Project H-541, Control Room Habitability.		working	5		03/31/88		Dugan
156	ROD /LT6	2.8.3	Creation of an alternate control room is supported.	Provided by H-644, Emergency Shutdown Panel.		working	09		05/31/87		Dugan
182	ROD /W11	2.8	Certain modifications to design requirements have been endorsed by many reviewers, such as, remote shutdown capability, control room habitability, and backup emergency core cooling. Assign priority attention to their accomplishment.	See related serial #'s for discussion.		working	5,13,24,09		03/31/88		Dugan

9. Equipment Qualification

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20	DES /5.7	2.9.2	Upgraded equipment qualification tests should be conducted on all ECCS performance related equipment exposed to a more severe environment during accidents.			working	46	FY89	06/30/87	*	Kester
25	DES /5.7	2.9.2	The exhaust valves should be tested under expected accident conditions.			working	47,50	FY89	06/30/87	*	Kester
46	DES /6.2.5	2.9.1	It is recommended that a formal EQ program be established for N Reactor for both electrical and mechanical safety related equipment. This development should be expedited. Include ECCS, HCR & Ball systems.	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	47,20	FY98	07/01/87	*	Kester
47	DES /6.2.5	2.9.1	It is recommended that a formal EQ program be established for N Reactor for both electrical and mechanical safety related equipment. This development should be expedited. Include confinement system, 0GCS.	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	46,25,17	FY98	07/01/87	*	Kester
50	DES /7.4	2.9.2	Develop a comprehensive valve testing program for safety related valves in confiner. (11.8.1)	The first valves for early testing and anlysis will be the RV-2 and V-43 valves. Other valves will be added based on the revised E.Q. plan and later the PRA and severe accident analysis results.		working		FY89	06/30/87	*	Kester

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88	SSR /V.C3	2.9.2	In the interest of further assuring the performance of the steam vent valves under accident conditions, verification testing of a valve should be performed to determine the effect of the wet steam release on its subsequent closure and seal tightness.	The overall program plan will include an environmental qualification program for electrical and mechanical systems and components. Early environmental tests will demonstrate the effect of wet steam on the valve closure and seal tightness.		working	25	FY88	04/30/87	*	Kester
140	SSR /TS	2.9.1	Analyze and test each component and sub-system of the confinement system to the maximum extent feasible to ensure its proper operation	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	25,47,80		07/01/87		Kester

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6	DES /4.2.3	2.10.6	Efforts to assure that tight administrative control of activities in the cable spreading room and other areas which are shared by protective systems should be reviewed and improved if needed.	Procedures for the control of activities in the cable spreading room (Rm 6) and similar areas, including Rm. 8, will be reviewed during the 1st quarter of FY87 and revised if needed to assure adequate protection of the protective systems.		working		4Q87	06/30/87	*	Jones
7	DES /4.2.3	2.10.1	UNC should develop procedures as described in 10 CFR 50, Appendix R, for achieving and maintaining a safe shutdown condition from outside the control room in the event of a fire in the cable spreading room.	An interim emergency procedure will be prepared prior to the end of the 1st quarter of FY87 (completed) describing the best methods for shutting down the reactor from outside the control room. Later, Project H-644 will provide an integrated remote	shutdown and monitoring location by the end of FY88. Procedure will be revised by 6/30/87 to reflect installation of remote shutdown panel.	complete	5	3Q87	12/31/86	*	Jones
49	DES /7.4	2.10.5	Poor review of emergency operating procedures. (I.C.7)	A review process has been proposed.		complete		4Q87	12/29/86	*	Jones
50	DES /7.4	2.10.5	Upgrade emergency operating procedures. (I.C.9)	Abnormal response guides will be developed for known N Reactor events which could lead to severe accident conditions. Emergency operating procedures will be developed in accordance with PRA results of risk significant sequences. EOP format to be sequence	oriented.	working	180,216	FY89	06/30/87	*	Jones
51	DES /7.4	2.10.3	Upgrade operator training in prevention and mitigation of severe accidents. (II.B.4)	Initial training in mitigating reactor core damage topics will be prepared and completed. Recertification training will provide training in specific PRA identified sequences.		working		FY88	06/30/87	*	Jones

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86	TSA /ER.3	2.10.7	Improve training for shift managers in their role as emergency director, especially for the period before the Emergency Control Center (ECC) cadre is assembled and the ECC chairman takes charge.	Improved training for the AED's was initiated in June, 1986. A formal lesson plan and ongoing training schedule will be in place by end of 3rd quarter FY87.		working	51	3Q87	06/30/87		Jones
90	TSA /ER.4-3	2.10.7	Ensure that the control room can be operated in the event that radioactive release or hazardous chemicals release requires donning self-contained breathing air equipment and/or protective clothing.	The SCBA program will be formalized and appropriate personnel trained.		working		3Q87	03/31/87	x	Jones
100	TSA /OA.7	2.10.8	Improve the execution of the provisions of the UNC "Fitness for Duty" program. Ensure better understanding of the program elements throughout the organization.	The "Fitness for Duty" program has been revised and will be fully implemented by the 2nd quarter FY87. Improved supervisor awareness training has been started.		working	96	FY88	04/30/87	x	Jones
104	TSA /OP.5	2.10.2	Improve the training and knowledge, company wide, of conditions under which graphite burns.	Reactor plant, training support and emergency center personnel to receive training.		complete	51	3Q87	02/28/87	x	Jones
123	TSA /TC.2-1	2.10.9	Require all charge/discharge fuel handling operations to be under the direct supervision of an individual certified by management as qualified to perform the required functions.	A training and certification program for charge/discharge supervisors will be in place by the end of 3rd quarter FY87.		working		4Q87	06/30/87	x	Jones
124	TSA /TC.2-2	2.10.3	Expand the training and certification program for current and future control room supervisors and shift managers to provide additional skills and knowledge in "non-credible" accident core thermal hydraulics, metal-water reactions, accident assessment	An interim program will be developed and completed in FY87. The complete final program must await PRA and other analysis results.		working	51	FY88	06/30/87	x	Jones

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125	TSA /TC.7-1	2.10.10	Upgrade the N Reactor system training manual (UNI-N-94) to provide current information important to plant operators including system operation characteristics, system interrelationships, and abnormal operations.	UNI-N-94 is kept up-to-date, but needs to be rewritten to provide the necessary detail to be utilized as an official study guide.		working		FY88	09/30/88		Jones
126	TSA /TC.7-2	2.10.4	Issue the simulator training plan as part of UNI-N-120 and develop simulator exercise guides.			complete	51	2Q87	02/28/87		Jones
133	TSA /DEB	2.10.11	Obtain independent certification of the adequacy of personnel qualification standards and training programs			working		FY88	09/30/87	*	Jones
170	RRB /77	2.10.4	Emphasis must continue on the training function including conforming manual and simulator performance to actual control room conditions and reactor behavior.	See related item.		complete	126		02/28/87		Jones
171	RRB /78	2.10.3	Continue to strengthen through education the onsite control room capability to respond to unusual and unanticipated events.	See related items.		working	51,124,126,104,86,98		06/30/87		Jones
175	RRB /84	2.10.4	Expand training programs to cover personnel involved in operation,maintenance,support, and supervision of N Reactor. Ensure training meets job requirements. Use INPO criteria for training and qualification and include review of simulator training.	See related items.		complete	126,170		02/28/87		Jones

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176	[illegible] /04	2.10.11	Arrange for INPO assistance followed by accreditation reviews by INPO.	See related item.		working	133		09/30/87		Jones
216	[illegible] /P33	2.10.5	The emergency procedures should be extended to include the possible symptoms that can appear in the more severe accidents that are recommended for analysis. Possible errors by operators in responding should be considered in the accident analysis.	See related items.			50,51		06/30/87		Jones
225	[illegible] /L51	2.10.3	There was also evidence of complacency at the plant, at the lower levels.	Enhanced severe accident training program to resolve.		working	51,104,124,171		06/30/87		Jones

11. Quality Assurance

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110	TSA /QA.1	2.11.1	Take steps to assure that the independent reporting channel to the UNC President for the Quality Assurance and Control Director works effectively.	UNC Management has assured that the personnel are familiar with the process for resolving quality issues. In addition, organization independence and the available reporting channels have been emphasized.		complete		4Q87	12/31/86	*	Schaffer
111	TSA /QA.15	2.11.1	Establish a system for control of non-conformance report tracking and for control of Non-Conformance Report materials in accordance with Quality Assurance Manual, UNI-M-73 Rev 1, QAR 15 requirements 3d. and 3g.			working		4Q87	04/01/87	*	Schaffer
112	TSA /QA.16	2.11.2	Establish mechanisms to assure that Corrective Action Requests which impact safety systems are promptly addressed.	The system has been developed.		complete	111	FY86	12/31/86		Schaffer
113	TSA /QA.17	2.11.3	Provide suitable storage for records that meet the definition for "Lifetime Records". Provisions should be made to backup (e.g. copy or microfilm) important records that may be lost or damaged.			working		FY99	06/30/87	*	Schaffer
114	TSA /QA.18-1	2.11.4	Provide for timely closure of quality assurance audit findings.			complete		4Q87	12/31/86	*	Schaffer
115	TSA /QA.18-2	2.11.4	Develop a master list of UNC activities, facilities, departments, and functions which should be subjected to periodic quality assurance audits for audit planning.			complete		4Q87	12/31/86	*	Schaffer

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116	TRA /QA.2	2.11.5	Build on the current Quality Assurance Program activities to emphasize the prevention of conditions adverse to quality.	Revised program under development and QA department reorganization in progress to implement the revised approach.		working		FY88	03/31/87	x	Schaffer
117	TRA /QA.6	2.11.6	Improve the document control system to assure that all documents requiring revision, based on changes to another document, are revised in a timely manner.	A study was completed to identify potential problems and suggest improvements. Implementation expected by 06/30/87.		working		FY89	06/30/87	x	Schaffer
138	TRA /TR.3-2	2.11.7	Develop a more comprehensive and integrated N Reactor trend analysis program to assure that all performance, safety, administrative and management issues are being evaluated.			working		FY88	06/30/87	x	Schaffer
183	ORR /012	2.11.8	Improve the effectiveness of the quality and quality assurance programs at the N Reactor.	See related items.		working	108,111,114-116		03/31/87		Schaffer

12. Non-Accelerated Recommendations

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2	DES /4.2.3	2.5.6	Raise the sensitivity of detection of small coolant leaks commensurate with understandings developed above.	An engineering study on leak detection and prevention will be completed and a program (if required) will be established.		not started		FY89	09/30/88		BA
10	DES /4.4.4	2.7.3	A flood hazard assessment should be undertaken to better understand the threat of flooding at the site.(DOE-RL program).	DOE to establish completion date. Results to be evaluated in conjunction with Recommendation # 11.		working		FY88	07/31/88		BA
11	DES /4.4.4	2.7.3	A modern flood analysis is recommended.	A review of the DOE state-of-the-art flood assessment, including upstream dam failures, will be performed to determine whether additional studies are required to improve confidence in flood levels established in earlier studies by the Corps	of Engineers and Bureau of Reclamation. If required, new studies will be completed by the end of FY88. The results of these studies will be utilized to respond to recommendation # 13.	on-hold		FY88	07/31/88		BA
13	DES /4.5.6	2.7.3	It is recommended that the 181-N building be evaluated for flood conditions identified in the studies proposed including dynamic wave effects.	An Engineering Analysis will be completed in FY88 using a modern flood analysis. (See Recommendation #11). Meanwhile, the evaluation is proceeding ona low priority basis.		working		FY88	07/31/88		BA
14	DES /4.5.6		Consider adding additional seismic instruments at key locations in the plant to provide plant response data should an earthquake occur.	Information from the seismic instruments recommended could be useful to evaluate whether the plant could be restarted after a severe earthquake. The instruments contribute nothing to the prevention of damage to the plant due to a seismic event. The	N Reactor already has in place seismiscopes that would activate the nuclear shutdown systems in the event of even a small seismic event. Thus, no action is planned at this time.	complete		FY89	10/31/86		BA

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32	DES /5.7	2.8.5	The pressure tube flow-monitoring system should be evaluated to determine if a better, more available instrument exists.	Currently the system has been upgraded by replacing aging capacitors, correction of workmanship deficiencies, and upgrading test methods and procedures. Further upgrades are in planning.		working		FY91	09/30/87		DA
53	DES /7.4	2.1.4	Upgrade safety parameter display. (I.D.2)	An Engineering Study will be completed in 4th quarter FY87 to re-evaluate the feasibility of using the IRIS/LAN system as an SPDS. The scope of follow on activities will be determined by the Engineering Study.		working	55	FY89	09/30/87		DA
54	DES /7.4	2.1.4	Determine whether post accident sampling of primary coolant would improve operator's ability to respond to the accident. (II.B.3)			working	58	FY88	09/30/88		DA
55	DES /7.4	2.6.4	Upgrade instrumentation to evaluate severe accidents. (II.F.1 and II.F.3)	An Engineering Study to determine instrumentation required to evaluate severe accidents will be conducted as information from the PRA becomes available. Upgrades to the instrumentation will be incorporated in FY88.		not started		FY90	09/30/88		DA
76	SGR /IV.B3	2.2.3	The Team recommends that hydrogen levels in the inert gas should be monitored, either through the gas chromatograph system or other means, to further strengthen the present gas monitoring system.	The system for monitoring hydrogen in the inert reactor gas atmosphere was installed in 4th quarter FY86 by authority of a Development Test. If tests prove successful, the monitor will be upgraded to full service in 3rd quarter FY87.		working		3Q87	06/30/87		DA

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77	SGR /IV.B3	2.6.4	The Team recommends that the reliability and availability of the gas inerting system as a safety related system be re-evaluated in view of its role in preventing fires/explosions and that new Technical Specifications should be established, if necessary.	The re-evaluation recommended will be implemented by performing a probabilistic risk assessment (PRA) and degraded core analyses including specific attention to the potential for inleakage of air into the reactor stack and the generation of hydrogen that	could be released to the stack. The results of these analyses will provide the bases for determining what upgrades are needed to improve the reliability/availability of the gas inerting system and/or modifications to the Technical Specifications.	not started		0087	03/31/88		NA
105	TSA /OP.7-1	2.1.4	Improve the control room annunciation systems.	An engineering study will be completed in FY88 to identify appropriate human factors criteria to be applied to the 105-N Control Room. Preliminary Design and procurement will be initiated in FY88 with estimated completion in FY89.		working		FY89	09/30/89		NA
106	TSA /OP.7-2	2.8.3	Reduce work area temperatures in building 109-N as to provide longer working times for operators on hot days.	Project H-671, 109-N HVAC Upgrade (currently cancelled), will be re-evaluated for current justification. Re-evaluation to be completed by the end of FY87. If justified, funding will be requested for design in FY88.		on-hold		FY90	09/30/87		NA
217	NRB /P36	2.5.6	On-line sampling of the primary water coolant to monitor chemical conditions should be restored.						07/31/88		NA

APPENDIX B—DATABASE BY ACCELERATED COMPLETION DATE

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14	NES /4.5.6		Consider adding additional seismic instruments at key locations in the plant to provide plant response data should an earthquake occur.	Information from the seismic instruments recommended could be useful to evaluate whether the plant could be restarted after a severe earthquake. The instruments contribute nothing to the prevention of damage to the plant due to a seismic event. The	N Reactor already has in place seismoscopes that would activate the nuclear shutdown systems in the event of even a small seismic event. Thus, no action is planned at this time.	complete		FY89	10/31/86		NR
84	TSA /ER.1	2.1.1	Revise Emergency Planning documentation to clearly define authorities and responsibilities of the shift manager and the designated Emergency Control Center chairman.	UNI-M-2 Vol 1 "Emergency Preparedness Manual" has been changed to clarify assignment of responsibility.		complete		3Q87	11/30/86	Y	Pysel
107	TSA /PP.5	2.1.2	Evaluate local exhaust ventilation systems to assure compliance with American Conference of Governmental Industrial Hygenists Ventilation Manual.	At the request of UNC, HEHF conducted an evaluation of local exhaust ventilation systems in UNC facilities during 1986.		complete		1Q87	11/30/86	Y	Pysel
85	TSA /ER.2	2.8.4	Provide for operational support during an emergency as outlined in NUREG 0737, Supplement 1 - "Clarification of TMI Action Plan Requirements".			complete	87	FY88	12/10/86	Y	Dugan
95	TSA /ER.6-5	2.1.1	Improve personnel accountability to assure a time of thirty minutes is met, as required by most commerical nuclear plants.	The PSN Accountability system initiated in FY86 will be completed and become a functioning part of N Reactor Evacuation Program.		complete		4Q87	12/10/86	Y	Pysel
87	TSA /ER.4-1	2.8.4	Interim upgrade of emergency control center.	The interim 100N Emergency Control Center has been relocated away from 100N.		complete		4Q87	12/15/86	Y	Dugan

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49	DES /7.4	2.10.5	Peer review of emergency operating procedures. (I.C.7)	A review process has been proposed.		complete		4Q87	12/29/86	n	Jones
35	DES /6.1.1.4	2.4.2	The pressure tube rupture analysis (3) should be improved as discussed in 6.1.1.3.	Detailed seismic and thermal hydraulic analysis of the reactor core was performed in 1985 which demonstrated that seismic events or pressure tube ruptures would not result in propagating failures or prevent safety systems in performing design functions.	Additional studies were implemented in June 1986 to study pressure tube axial splits and reflood transients.	complete	36	3Q87	12/30/86	n	Galiato
65	DES /8.7	2.4.2	The severe accident which would be initiated by a propagating failure of pressure tubes and its impact on graphite stack disruption with respect to capability to shut down reactor power operation, should be analyzed on a best-estimate basis.	Single pressure tube breaks were analyzed in 1985 and demonstrated that tube failures would not propagate. Recent analysis for both circumferential and longitudinal breaks with more current analysis tools has reconfirmed the previous analysis. Thus it is	concluded that propagating tube ruptures is not a credible event.	complete	64	4Q87	12/30/86	n	Galiato
139	NAS /B4	2.4.2	Study the possible effects of a longitudinal split type break in an embrittled Zirconium alloy process tube within the graphite and the stresses on adjacent tubes which could propagate in the core and result in a Chernobyl-like accident.	Detailed seismic and thermal hydraulic analysis of the reactor core was performed in 1985 which demonstrated that seismic events or pressure tube ruptures would not result in propagating failures or prevent safety systems in performing design functions.	Additional studies were implemented in June 1986 to study pressure tube axial splits and reflood transients.	complete	35		12/30/86		Galiato
7	DES /4.2.3	2.10.1	UNC should develop procedures as described in 10 CFR 50, Appendix R, for achieving and maintaining a safe shutdown condition from outside the control room in the event of a fire in the cable spreading room.	An interim emergency procedure will be prepared prior to the end of the 1st quarter of FY87 (completed) describing the best methods for shutting down the reactor from outside the control room. Later, Project B-644 will provide an integrated remote	shutdown and monitoring location by the end of FY88. Procedure will be revised by 6/30/87 to reflect installation of remote shutdown panel.	complete	5	3Q87	12/31/86	n	Jones

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97	TSA /MA.2-1	2.1.2	Improve the method of ensuring that all plant material deficiencies are promptly identified and are entered into the Work Authorization system.	Operations and maintenance addressed the problem by reviewing the Work Authorization control system for deficiencies and making selected improvements.		complete		4Q87	12/31/86	*	Pyzel
108	TSA /QA.1	2.11.1	Take steps to assure that the independent reporting channel to the UNC President for the Quality Assurance and Control Director works effectively.	UNC Management has assured that the personnel are familiar with the process for resolving quality issues. In addition, organization independence and the available reporting channels have been emphasized.		complete		4Q87	12/31/86	*	Schaffer
112	TSA /QA.16	2.11.2	Establish mechanisms to assure that Corrective Action Requests which impact safety systems are promptly addressed.	The system has been developed.		complete	111	FY86	12/31/86		Schaffer
114	TSA /QA.10-1	2.11.4	Provide for timely closure of quality assurance audit findings.			complete		4Q87	12/31/86	*	Schaffer
115	TSA /QA.10-2	2.11.4	Develop a master list of UNC activities, facilities, departments, and functions which should be subjected to periodic quality assurance audits for audit planning.			complete		4Q87	12/31/86	*	Schaffer
154	ROD /LT4	2.6.3	Probabilistic risk analysis should be expedited.	See # 78.		complete	4,16,69,78		01/01/87		Knapp
157	ROD /T4	2.6.3	Expedite and expand the PRA analysis. The contractor should be intimately involved, but because of the magnitude and urgency, it should be assigned to one org who will draw on resources of other groups. Some questions should not wait for PRA results.	See # 78.		complete	4,16,69,78		01/01/87		Knapp

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190	RDD /P9	2.6.3	Expedite conduct of a level 3 PRA. Ensure that personnel who will have long-term involvement with the N Reactor participate.	See # 78.		complete	4,16,67,78,163		01/01/87		Knapp
195	RDD /P11	2.6.3	The accidents at Chernobyl and TMI show that accidents can happen, from design or operator error or both. Relying on a specified design-basis accident is not sufficient to assure safety. Include operator error and severe core damage in accident analysis.	Operator reliability is an integral part of the Level 1 PRA models. High frequency events leading to core damage will be completely analyzed in the Level 2 effort.		complete	4,16,67,78		01/01/87		Knapp
200	RDD /P10	2.6.3	Accident analysis should include accidents involving operator error and accidents involving severe core damage	See # 195.		complete	4,16,67,78		01/01/87		Knapp
205	RDD /P23	2.6.1	The MUSAR calculations are competently done, but the calculated max temp is close to the threshold temp for autocatalytic zirc-water reaction, thereby questioning the assumption that this type accident is suitable for the basis of confinement design.	Reaction kinetics for metal oxidation are governed by well known rate equations and the system heat transfer and heat generation. Complex computer models are used to evaluate these phenomena.		complete	22,44,79		01/01/87		Knapp
213	RDD /P32	2.6.2	The N design analysis seems unrealistic in the calculation of flow of the gas phase from one compartment to another.	These calculations have been revised with current analytical tools and have been found to be correct.		complete			01/01/87		Knapp
218	RDD /P37	2.6.3	A full probabilistic risk assessment of the N Re involving the N safety managers and designers as well as independent outside groups would be preferable to the two parallel assessments now underway.	External review is being performed for the UNC PRA to assure conformance to accepted industry practices. The reviewers represent many facets of industry. UNC staff are integrally part of the PRA efforts.		complete	4,16,67,78		01/01/87		Knapp

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220	ROB /P30	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of doubt that hydrogen will be so rapidly mixed within the confinement compartments that hydrogen burning cannot occur.	Re-analysis of the hydrogen mixing and transport within the confinement compartments with updated analytical methods has confirmed the validity of the 1978 conclusions.		complete	219		01/01/87		Knapp
221	ROB /P30	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of the need to install ignitors or to inert the confinement to prevent hydrogen explosion.	The 1978 NUSAR technical position on hydrogen mixing in Building 109 has been confirmed in recent studies. Hydrogen concentrations will not reach limits at which burning or explosions are predicted.		complete	219,220		01/01/87		Knapp
163	ROB /LS10	2.1.1	It is essential that the improvements recommended by fellow consultants be implemented, with full awareness of the fact that too many changes at once can be antithetical to safety. Therefore, the team must provide priority lists for the recommendations.	The accelerated program addresses the priority and scheduling of improvements.		complete			01/07/87		Pysel
79	ESR /C.A3	2.6.1	The Team recommends that computer models of the accidents that form the confinement system design basis continue to be maintained current and be based on current probabilistic risk assessments.	WHC plans to maintain the computer models current - this recommendation does not represent any additional activity or effort. This subject is addressed in much more detail in the later reviews, and therefore we consider it closed.		complete	22	4Q87	01/09/87	*	Knapp
127	TOA /15.2	2.1.1	Revise UNI-M-89 SI-6, "Safety and Environmental Engineering Instruction Manual", to clearly state the conditions under which a Production Test or Development Test procedure can or cannot be reused and what approvals are required.	A study has been completed and procedures upgraded as required.		complete	16	1Q87	01/31/87		Pysel

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41	GCS /6.1.1.4	2.4.2	The effects of possible graphite cooling tube water impinging on an embrittled pressure tube should be analyzed.	Operating procedures and requirements provide that the reactor be shutdown upon confirmed leakage within the graphite moderator. Leak detection methods include monitoring of water collection rates from the dryers, gas system dew points, and flow	monitoring of all cooling tubes withing the moderator. An evaluation was performed to determine the magnitude and potential consequences of a local cold spot caused by water from a GCS tube impinging on the outer circumference of a pressure tube.	complete	36	1Q87	02/28/87		Bellete
102	TSA /OP.2	2.1.1	Improve controls over operator aids such as drawings, references and sketches to assure that only correct, updated and approved information is used by the operator.	Controls have been developed and formalized into UNI-M-152. Implementation is on schedule.		complete		2Q87	02/28/87		Pysel
104	TSA /OP.5	2.10.2	Improve the training and knowledge, company wide, of conditions under which graphite burns.	Reactor plant, training support and emergency center personnel to receive training.		complete	51	3Q87	02/28/87	x	Jones
110	TSA /OA.13	2.1.3	Improve storage, segregation, and marking of chemicals, reagents, lubricants, solvents, and other flammable materials in accordance with the requirements of ANSI/ASME NQA-1 and UNC QA Requirement 13-3.3.			complete		FY88	02/28/87	x	Pysel
126	TSA /TC.7-2	2.10.4	Issue the simulator training plan as part of UNI-M-120 and develop simulator exercise guides.			complete	51	2Q87	02/28/87		Jones
170	[illegible] /T7	2.10.4	Emphasis must continue on the training function including conforming manual and simulator performance to actual control room conditions and reactor behavior.	See related item.		complete	126		02/28/87		Jones

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175	BOD /04	2.10.4	Expand training programs to cover personnel involved in operation,maintenance,support, and supervision of N Reactor. Ensure training meets job requirements. Use INPO criteria for training and qualification and include review of simulator training.	See related items.		complete	126,170		02/28/87		Jones
71	DES /9.13.4	2.7.2	Review whether equipment in the vicinity of the 189-N batteries can fall and damage batteries.	See # 12.		working	12	3Q87	03/13/87	*	Kelly
75	DES /9.13.4	2.7.2	Review portable emergency lighting throughout the plant to ensure that this equipment will not fall from supports during a seismic event.	See # 12.		working	12	3Q87	03/15/87	*	Kelly
12	DES /4.5.6	2.7.2	It is recommended that the concrete block superstructure portions of the 181-N and 182-N Buildings be re-examined for possible wind damage to the walls and the possibility of the blocks falling on vital equipment housed within these facilities.	An Engineering Analysis will be completed in March 1987. Any problems will be identified and an action plan developed for implementation of and corrective action identified.		working		3Q87	03/20/87	*	Kelly
72	DES /9.13.4	2.7.2	Review whether concrete blocks near building 181-N can fall and damage the batteries. Review whether concrete blocks can fall and damage diesel peripherals including fuel lines.	See # 12.		working	12	3Q87	03/20/87	*	Kelly

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70	DES /9.13.4	2.7.2	Review the seismic adequacy of the suspended ceiling and electrical cabinets in the control room.	See # 12.		working	12	3Q87	03/30/87	N	Kelly
74	DES /9.13.4	2.7.2	Review the silo near building 182-N for strength and deformation of the pipe connections.	See # 12.		working	12	3Q87	03/30/87	N	Kelly
98	TSA /ER.4-3	2.10.7	Ensure that the control room can be operated in the event that radioactive release or hazardous chemicals release requires donning self-contained breathing air equipment and/or protective clothing.	The SCBA program will be formalized and appropriate personnel trained.		working		3Q87	03/31/87	N	Jones
116	TSA /QA.2	2.11.3	Build on the current Quality Assurance Program activities to emphasize the prevention of conditions adverse to quality.	Revised program under development and QA department reorganization in progress to implement the revised approach.		working		FY88	03/31/87	N	Schafter
118	TSA /RP.11-1	2.1.2	Clean up control zones. Clearly mark and/or identify and neatly store necessary tools, instruments and equipment.	Operations and maintenance are developing plans to improve radiation zone control and housekeeping.		working		FY89	03/31/87	N	Pyzel
119	TSA /RP.11-2	2.1.2	Develop and implement the philosophy and practice of cleaning up the source of uncontained contamination and/or design facilities with the objective of containing contamination at the source.	Plan being developed. Temporary measures implemented Aug 1,1986.		working		FY89	03/31/87	N	Pyzel

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122	TBA /RP.5	2.1.2	Evaluate and work with Pacific Northwest Laboratory and UB Testing to assure that critical personnel dosimeter processing and storage facilities (managed by UB Testing) are adequately protected from fire loss.	A study of PNL and UB testing methods and facilities to assure protection of vital data will be concluded and recommendations made to both contractors.		working		FY86	03/31/87		Pysel
174	NAS /T12	2.3.7	N Reactor confinement is designed to provide for controlled releases to the environment under accident conditions. Questions remain as to whether components operate as designed and programmed. Continued surveillance and testing of components is necessary	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values, and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts	and the continued surveillance tests are designed to fulfill this recommendation.	working	8,26,27,etc.		03/31/87		Schmidt
183	NAS /M12	2.11.8	Improve the effectiveness of the quality and quality assurance program at the N Reactor.	See related items.		working	108,111,114-116		03/31/87		Schaffer
187	NAS /P2	2.3.7	Resolve the uncertainties in performance of the N Reactor confinement system.	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts	and the continued surveillance tests are designed to fulfill this recommendation.	working	8,26,27,47,60		03/31/87		Schmidt
201	NAS /P19	2.3.7	Adequate confinement or containment is needed to protect the public from radioactivity released in a serious accident.	A technical document will be prepared on confinement describing its design, operation, tech spec surveillance testing, resulting reliability values and its appropriateness for N Reactor. In conjunction with testing under related tasks, these efforts and	the continued surveillance tests are designed to fulfill this recommendation.	working	187		03/31/87		Schmidt

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111	TSA /QA.15	2.11.1	Establish a system for control of non-conformance report tracking and for control of Non-Conformance Report materials in accordance with Quality Assurance Manual, UNI-M-73 Rev 1, QAR 15 requirements 3d. and 3g.			working		4Q87	04/01/87	*	Schaffer
150	ORD /L19	2.1.1	DOE and Contractor safety responsibilities should be better defined.	A review is underway to assure that safety responsibilities are clearly defined and understood. The review will be completed by 4/1/87 and identified action items will be assigned for prompt completion.		working			04/05/87		Pyzel
73	DES /9.13.4	2.7.2	The same recommendation as for building 181-N applies to building 182-N. Also, review the buried fuel tanks and lines. Review the large vertical tanks adjacent to building 182-N for both seismic and wind loading.	See # 12.		working	12	3Q87	04/15/87		Kelly
10	DES /5.7	2.6.2	Xenon instability analyses should be updated and include an analysis of stability against azimuthal xenon oscillation coupled with thermal-hydraulic effects resulting from the semi-independence of cooling of the two halves of the reactor.	Conservative analyses of N-Reactor confirm observations that the core is stable towards Xe or power oscillations. Observation of the process tube outlet temperatures and power range monitors have not indicated a presence of azimuthal Xe oscillations.	This question will be further explored with experimental measurements following the installation of the in-core detector system and analytically using a special three-dimensional core analysis code by the mid FY87.	working		FY88	04/30/87	*	Knapp
43	DES /6.1.2.2	2.4.2	The possible pressure tube strains and stresses resulting from credible graphite block offsets should be quantified and compared to failure strains.	The effects of gradual graphite distortion have been studied as has dynamic displacement of graphite caused by postulated tube rupture and earthquake loads. The effect of localized graphite block displacements (offsets) will be quantified by analysis by	the third quarter of FY87. The resulting report will indicate necessary follow-on actions including tests as described in # 42.	working	36	4Q87	04/30/87	*	Kalista

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60	OCS /7.4	2.3.3	Protect containment relief valves from blockage from debris. (II.E.4.2)	The engineering study will be completed in March 1987. Cable tray concerns will be corrected in March 1987. Any other resulting recommendations will be scheduled based on their potential consequences at the conclusion of the study.		working	47,25	FY88	04/30/87	*	Schmidt
67	DES /9.13.1	2.1.3	DC Switchgear : Additional precaution should be taken to ensure the flammable liquids cannot be used outside the door leading to room which could leak or spill into room 8, especially during reactor operations.	See # 6.		working	6	2Q87	04/30/87		Pyzel
83	TSA /AI.7	2.7.2	Evaluate potable water tank and fog spray accum tank for earthquake resistance.	See # 12.		working	12	FY86	04/30/87		Kelly
94	TSA /ER.6-4	2.1.3	Evaluate the feasibility of replacing the liquid chlorine facilities for treatment of demineralized primary system makeup water with a less hazardous system.	An Engineering Study will be completed and a program (if required) will be established by end of 4th quarter FY87.		working		3Q87	04/30/87		Pyzel
100	TSA /OA.7	2.10.0	Improve the execution of the provisions of the UNC "Fitness for Duty" program. Ensure better understanding of the program elements throughout the organization.	The "Fitness for Duty" program has been revised and will be fully implemented by the 2nd quarter FY87. Improved supervisor awareness training has been started.		working	96	FY88	04/30/87	*	Jones
81	TSA /AZ.1	2.5.2	Provide facilities to enable rapid detection of a leak from the liquid waste collection tank (1310-N Tank) and from the associated inlet and outlet lines which are underground.	A level detector has been installed. Preliminary design for test wells to monitor leakage is underway. Reliable tank inventory monitoring provides for early detection of any leaks of N Reactor decontamination waste.		working		FY89	05/15/87	*	Blankenship

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65	NES /0.6.3	2.5.5	It is recommended that the desirability of treating crib water with sodium hydroxide to limit iodine re-evolution should be evaluated.	An evaluation is being performed. Based on results, a plant modification and procedure changes may be required as part of a new program.		working	66	FY88	05/31/87	x	Blankenship
89	TSA /ER.4-2	2.8.3	Install remote shutdown capability at N Reactor for emergency shutdown of the reactor from outside the control room.	Project H-644, Emergency Shutdown Panel, has concluded the Definitive Design Stage and is currently scheduled to finish construction by May 1987.		working		FY88	05/31/87	x	Rogan
156	NRD /L16	2.8.3	Creation of an alternate control room is supported.	Provided by H-644, Emergency Shutdown Panel.		working	89		05/31/87		Rogan
146	NRD /R16	2.6.2	...available chemical energy from metal-water reactions is significantly greater in "N" and Chernobyl-4 than in TMI-2. Table 1 also shows that the potential hydrogen evolution at the "N" reactor is 20 times that of a TMI-2 and twice that of a Chernobyl-4.	Potential chemical energy conversion from reactor components is controlled by chemical process and rarely is all of the potential energy available in real reaction situations. Codes being developed will consider chemical thermodynamics and kinetics in	the analysis of severe accidents. The amount of zirc metal cladding available for reaction is similar for each reactor system using criteria specified in 10 CFR 50. The zirc cladding mass in N, Chernobyl, and a LWR is 22.7, 53, & 20.2 metric tons respct.	working	56,77,179		06/01/87		Knapp
149	NRD /T6	2.6.2	Re-evaluate the expected chemical forms and quantities of iodine release and the effectiveness of the spray and filter systems in their removal.	Evaluation of expected chemical forms will be accomplished through a thorough survey of literature, possible small scale tests and analysis with upgraded analytical tools (see 022). Evaluation of fog spray effectiveness will be performed with the up-	graded fission product transport codes in support of the Level 2 PRA.	working	22,66,79,etc.		06/01/87		Knapp

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190	ROD /P5	2.6.2	Update the safety analysis of the chemical form and amounts of fission products that will be evolved from overheated fuel.	See # 169.		working	22,66,79,169		06/01/87		Osapp
192	ROD /P7	2.6.2	Analyze the different chemical and physical forms of radioactivity that can be released to the confinement under accident conditions.	See serial # 169.		working	22,66,79,4,16,69,70,169		06/01/87		Osapp
227	ROD /P13	2.6	Uncertainties in the predictions of N Reactor confinement now question the level of safety that was concluded in the 1978 Safety Review of N Reactor. N Reactor does not meet some of the tighter safety standards that have evolved after the TMI accident.	PRA to resolve.		working	4,16,23,62		06/01/87		Osapp
42	DES /6.1.1.4	2.4.2	Tests be performed to ensure that pressure tubes cannot be failed by local graphite offsets of the type described in Section 6.1.2 below.	See # 43.		working	36	4Q87	06/13/87	Y	Galioto
93	TSA /EX.6-3	2.1.1	Correct deficiencies in the plant annunciating and emergency response warning systems to assure they can be heard in all areas of the plant.	An action plan will to in place by end of 4th quarter FY86 with corrective action (including any necessary equipment changes) by end of 3rd quarter FY87.		working		4Q87	06/15/87	Y	Pysel
1	DES /4.2.3	2.4.1	A program to understand the "leak-before-break" characteristics of the carbon steel primary coolant system piping should be undertaken.	Leak-before-break is an important issue for LWR's built with stainless steel piping. N Reactor's piping is carbon steel, which does not have the same problems with stress corrosion cracking as stainless steel. The primary piping is inspected for leaks	during a primary hydro prior to each startup, about every five weeks. Selected thickness measurements will be made on the carbon steel piping.	working		FY88	06/30/87	Y	Galioto

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6	OES /4.2.3	2.18.6	Efforts to assure that tight administrative control of activities in the cable spreading room and other areas which are shared by protective systems should be reviewed and improved if needed.	Procedures for the control of activities in the cable spreading room (Rm 6) and similar areas, including Rm. 8, will be reviewed during the 1st quarter of FY87 and revised if needed to assure adequate protection of the protective systems.		working		4Q87	06/30/87	*	Jones
20	OES /5.7	2.9.2	Upgraded equipment qualification tests should be conducted on all ECCS performance related equipment exposed to a more severe environment during accidents.			working	66	FY89	06/30/87	*	Koster
22	OES /5.7	2.6.1	Analytical tools used for thermal hydraulic analyses should be upgraded as appropriate with emphasis on best estimate capability.	The ongoing effort to develop upgraded tools has been accelerated. Codes have been selected for system analysis (RELAP5,TRUMP-BD, SCDAP) containment system analysis (HECTR,COBRA-NC), and fission product transport (TRAP-MELT, CONTAIN). Model development	will be complete in FY87.	working		3Q87	06/30/87		Knapp
25	OES /5.7	2.9.2	The exhaust valves should be tested under expected accident conditions.			working	47,88	FY89	06/30/87	*	Koster
28	OES /5.7	2.6.2	A study should be conducted on the possible benefits of operating the confinement systems at sub-atmospheric pressures, once the steam vent valves are closed.	An evaluation will be performed using upgraded analytical tools. The study will support re-evaluation of proposed hydrogen mitigation schemes and the Level 2 PRA.		working		FY88	06/30/87	*	Knapp
31	OES /5.7	2.1.1	A more aggressive and formal system to make use of operating and safety review information from N Reactor and commercial LWRs should be established.	Shortly after joining INPO in 1981, UNC initiated a program to review and disseminate operating information. To upgrade this effort, a dedicated group will be organized in FY87 and procedures will be upgraded to more clearly establish responsibilities	for translating recommendations into action.	working		4Q87	06/30/87	*	Pyzel

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48	DES /7.4	2.1.1	Use operating experience at N Reactor and the LWR's to evaluate possible precursors to severe accidents. (I.C.3)	See # 31.		working	31	4Q87	06/30/87	*	Pyzel
50	DES /7.4	2.10.5	Upgrade emergency operating procedures. (I.C.9)	Abnormal response guides will be developed for known N Reactor events which could lead to severe accident conditions. Emergency operating procedures will be developed in accordance with PRA results of risk significant sequences. EOP format to be sequence	oriented.	working	100,216	FY89	06/30/87	*	Jones
51	DES /7.4	2.10.3	Upgrade operator training in prevention and mitigation of severe accidents. (II.B.4)	Initial training in mitigating reactor core damage topics will be prepared and completed. Recertification training will provide training in specific PRA identified sequences.		working		FY88	06/30/87	*	Jones
58	DES /7.4	2.9.2	Develop a comprehensive valve testing program for safety related valves in confiner. (II.D.1)	The first valves for early testing and anlysis will be the RV-2 and V-43 valves. Other valves will be added based on the revised E.O. plan and later the PRA and severe accident analysis results.		working		FY89	06/30/87	*	Keskar
59	DES /7.4	2.6.2	Confirm present assumptions regarding response to LOCA's caused by small openings in the pressurizer. (II.D.3)	The subject transient will be analyzed with upgraded codes in support of the Level I PRA.		working	23	4Q87	06/30/87		Rapp
76	SSR /IV.B5	2.2.3	The Team recommends that hydrogen levels in the inert gas should be monitored, either through the gas chromatograph system or other means, to further strengthen the present gas monitoring system.	The system for monitoring hydrogen in the inert reactor gas atmosphere was installed in 4th quarter FY86 by authority of a Development Test. If tests prove successful, the monitor will be upgraded to full service in 3rd quarter FY87.		working		3Q87	06/30/87		NA

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80	SSR /V.C3	2.9.2	In the interest of further assuring the performance of the steam vent valves under accident conditions, verification testing of a valve should be performed to determine the effect of the wet steam release on its subsequent closure and seal tightness.	The overall program plan will include an environmental qualification program for electrical and mechanical systems and components. Early environmental tests will demonstrate the effect of wet steam on the valve closure and seal tightness.		working	25	FY88	06/30/87	*	Kester
86	TSA /ER.3	2.10.7	Improve training for shift managers in their role as emergency director, especially for the period before the Emergency Control Center (ECC) cadre is assembled and the ECC chairman takes charge.	Improved training for the AED's was initiated in June, 1986. A formal lesson plan and ongoing training schedule will be in place by end of 3rd quarter FY87.		working	31	3Q87	06/30/87		Jones
96	TSA /FR.4	2.1.1	Expand the scope of the annual facility safety review to include an independent audit of Reactor Control Room activities and maintenance of reactor-safety related equipment, with special attention to the competency of control room personnel.	The scope of the annual safety review will be revised/expanded such that the annual facility safety review to be conducted in FY87 will include control room and safety-related maintenance activities.		working		4Q87	06/30/87	*	Pysel
98	TSA /MA.2-2	2.1.2	Reduce the number of fluid system leaks in the plant.	A program to lessen non-primary leaks throughout the plant will be initiated in FY87. Reduction of unnecessary flow in the radioactive drain will reduce the burden on the soil column.		working		4Q87	06/30/87	*	Pysel
109	TSA /MA.12	2.1.2	Establish and implement a control system to ensure that tools, gauges, instruments, and other measuring or test devices are identified, controlled, calibrated, and adjusted at specific frequencies to assure necessary accuracies are maintained to verify..	Inventories of portable measuring and test equipment and bench measuring and test equipment are complete. Instruments in priority locations in the 105N and 109N Buildings have been inventoried for entry in the existing calibration control and recall	systems.	working		FY90	06/30/87	*	Pysel

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113	TSA /QA.17	2.11.3	Provide suitable storage for records that meet the definition for "Lifetime Records". Provisions should be made to backup (e.g. copy or microfilm) important records that may be lost or damaged.			working		FY89	06/30/87	*	Schaffer
117	TSA /QA.6	2.11.6	Improve the document control system to assure that all documents requiring revision, based on changes to another document, are revised in a timely manner.	A study was completed to identify potential problems and suggest improvements. Implementation expected by 06/30/87.		working		FY89	06/30/87	*	Schaffer
120	TSA /RP.12	2.1.2	Improve efforts to reduce exposure through the ALARA program for 1)total plant personnel, 2)the average individual, and 3)work groups, and establish specific measurable goals in each of these areas to consistently reduce doses.	Specific changes to the ALARA program have been determined.		working		FY90	06/30/87	*	Pyzel
123	TSA /TC.2-1	2.10.9	Require all charge/discharge fuel handling operations to be under the direct supervision of an individual certified by management as qualified to perform the required functions.	A training and certification program for charge/discharge supervisors will be in place by the end of 3rd quarter FY87.		working		4Q87	06/30/87	*	Jones
124	TSA /TC.2-2	2.10.3	Expand the training and certification program for current and future control room supervisors and shift managers to provide additional skills and knowledge in "non-credible" accident core thermal hydraulics, metal-water reactions, accident assessment	An interim program will be developed and completed in FY87. The complete final program must await PRA and other analysis results.		working	31	FY88	06/30/87	*	Jones

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129	TSA /TS.5-1	2.1.1	Integrate and more efficiently conduct the review process for the review and distribution of offsite "operating experiences" documents.	See # 31.		working	31	4Q87	06/30/87	x	Pyzel
130	TSA /TS.5-2	2.11.7	Develop a more comprehensive and integrated N Reactor trend analysis program to assure that all performance, safety, administrative and management issues are being evaluated.			working		FY88	06/30/87	x	Schaffer
132	TSA /TS.8	2.1.1	Provide a more comprehensive validation system for computer codes used for calculating operating limits.	A study will be completed and procedures upgraded as required.		working	96	4Q87	06/30/87	x	Pyzel
134	/	2.4.3	Install in-core neutron detectors.	Completion of construction is planned in FY87.		working			06/30/87		Galiata
135	/	2.4.3	Implement flux-flattening operation.	ABE of flux-flattening changes to be installed in FY87.		working		FY91	06/30/87		Galiata
143	NRD /R13	2.1.1	The present contractor is a "special" member of INPO. The Department should have this contractor, and his successor, make full use of the overview services of INPO, in the operations, maintenance, training and emergency preparedness field.	Contractor to obtain DOE approval to apply for full membership status.		working	133,31,60,120		06/30/87		Pyzel
148	NRD /R18	2.1.2	The present design, based on the earlier production reactors is very man-rem intensive during the reloading cycle.				120		06/30/87		Pyzel

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137	ROD /L17	2.1.1	INPO reviews of N Reactor operations should be instituted.	See related items.		working	133,31,48,129,145		06/30/87		Pyzel
164	ROD /L87	2.1.1	It would be worthwhile to ask INPO to conduct an operational review of the N Reactor.			working	145		06/30/87		Pyzel
171	ROD /T8	2.10.3	Continue to strengthen through education the onsite control room capability to respond to unusual and unanticipated events.	See related items.		working	51,121,126,104,84,98		06/30/87		Jones
173	ROD /T11	2.1.1	DOE should make greater use of external peer review groups to address reactor safety on a continuing basis. The use of external entities such as ACRS and INPO should be pursued.	Pertinent INPO services will be utilized (see related item).		working	49,145		06/30/87		Pyzel
177	ROD /H5	2.1.1	N Reactor is a special participant in INPO. Arrange for an early INPO operational evaluation. Arrange for continuing periodic INPO evaluations with their follow-up benefits.	See related items.		working	145		06/30/87		Pyzel
178	ROD /H6	2.1.1	Arrange for an INPO emergency preparedness review.	Reviews will be requested.		working	85,88,145		06/30/87		Pyzel
180	ROD /H13	2.1.1	Ensure that there is an effective on-site and off-site review of off-normal events that occur at the N Reactor to ensure that underlying root causes are identified so that corrective measures can be taken.	See related items.		working	94,112,116,133,145		06/30/87		Pyzel

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185	[illegible] /014	2.4	Expand surveillance and monitoring of the N Reactor to refine the estimate of date of end of normal life. In addition to zircalloy-2 tube embrittlement and graphite growth, include selected valves, systems, and components.	*This is a very broad effort, and encompasses ongoing activities in pressure tube and graphite surveillance/PIE, the ISI program efforts, and Equipment Qualification efforts. Inspection and tests required by the ASME code will be among the accelerated	activities.	working	35-40,47 45,136,137,27,47		06/30/87		Ballaio
195	[illegible] /77	2.6.1	Study the performance of an analytical technique that has been verified and validate, including verification with data on multicompartment removal systems and validation of assumptions of gas and liquid flow and mass-transfer kinetics.	Upgraded confinement analysis codes which are best-estimate and state-of-the-art will be developed to support the PRA analysis (see 022).		working	22		06/30/87		Baugo
196	[illegible] /78	2.6.1	Develop realistic predictions of confinement performance symptoms: time dependent pressure,temp,species, and radioactivity concentrations to be used in training confinement operators and in developing emergency procedures to mitigate confinement malfcns.	The upgraded analytical tools developed for N Reactor (see 022) will provide realistic predictions of confinement behavior. These codes will be used to perform analysis in support of the Level 2 PRA.		working	79,66,etc.		06/30/87		Baugo
197	[illegible] /79	2.1.1	N Reactor should become an active participant with INPO. Should implement safety management practices established for commercial reactors,and be audited periodically by INPO, and have its training program accredited by Nat'l Academy of Nuclear Training.			working	31,40,129,133		06/30/87		Pysel

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303	[illegible] /P21	2.1.1	Good safety practices subject to independent audit are necessary to avoid complacency, ensure accidents are prevented and mitigated, and to reduce the likelihood that unplanned for accidents will happen.	See related item.		working	96,113,133		06/30/87		Pyzel
316	[illegible] /P35	2.10.3	The emergency procedures should be extended to include the possible symptoms that can appear in the more severe accidents that are recommended for analysis. Possible errors by operators in responding should be considered in the accident analysis.	See related items.			30,31		06/30/87		Jones
325	[illegible] /L58	2.10.3	There was also evidence of complacency at the plant, at the lower levels.	Enhanced severe accident training program to resolve.		working	53,104,120,171		06/30/87		Jones
3	OES /4.2.3	2.5.1	Efforts to reduce primary coolant system leakage should be vigorously pursued.	System leakage has been reduced by the repair and replacement of several valves during the Valve Program. This effort will continue in FY87. An environmental upgrade program will continue efforts to reduce leakage. Also, efforts towards removal of	old, unneeded primary boundary valves will continue. Three of six sub-items have been accelerated by two years. Reduction of primary coolant leakage will reduce the radionuclides released to the environment.	working		FY88	07/01/87	*	Blankenship
8	OES /4.2.3	2.3.2	The extent of testing of the confinement system should be increased to provide additional confidence that the system will satisfy its confinement function following a design pressure transient.	Confinement system boundary will be tested at a higher pressure to assure leak-tightness and validity of accident dose rate calculations at the filtered release pressure.		working	8,26,27,47	FY90	07/01/87	*	Schmidt

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21	DES /5.7	2.7.3	Steps should be taken to improve separation between ECCS equipment trains in the 102-N building.	Specific steps to improve isolation of DC controls in the 102N building have been identified and will be implemented in FY87. Design for this task is underway. Also a project to improve fire protection, separation of the 102N and 107N ECCS/Fog Spray	diesels will be completed in FY87.	working		FY89	07/01/87	N	Kelly
26	DES /5.7	2.3.2	The entire confinement system should be tested at as high a pressure as feasible and practical.	Confinement system boundary will be tested at a higher pressure to assure leak-tightness and validity of accident dose rate calculations at the filtered release pressure.		working	8,27	FY88	07/01/87	N	Schmidt
27	DES /5.7	2.3.1	Selected components should be tested at design pressure.	This task will focus on the qualification of confinement system penetrations under accident pressure conditions.		working	8,26	FY88	07/01/87	N	Schmidt
29	DES /5.7	2.2.2	The effect of a hydrogen burn on the stack filters and doors should be studied rigorously for potential failure.	This task will be resolved by the prevention of hydrogen burning. For additional discussion see related item.		working	36	FY88	07/01/87	N	Franz
30	DES /5.7	2.3.5	The decontamination factor for Hydrogen iodide of activated charcoal filters should be determined.	Evaluations will be performed in FY87. These will include a literature survey and appropriate tests and analyses.		working		4Q87	07/01/87	N	Schmidt
36	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : sensitive NDE inspections be performed of a minimum of 30, and preferably 100,pressure tubes per year.	Current plans for sensitive NDE are for initial inspections of a limited number of tubes in 1987 to qualify the inspection equipment. Annual inspections of fifty or more tubes will be planned, starting in FY87 with an annual reassessment of the number	planned for subsequent years. Numbers of inspections will depend upon results of prior inspections and inspection program requirements. FY87 inspections to be performed by 6/30/87 will not involve detailed evaluation of results.	working		4Q87	07/01/87	N	Galinko

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37	NES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : at least 2 tubes be removed and metallurgically examined per year.	Two tubes were removed for examination in 1986. Testing and evaluation of these have been completed. Four tubes will be removed in FY87 and preliminary examinations of prime cut sections completed by the fourth quarter. Two tubes a year will be removed	after FY87.	working	36	[illegible]	07/01/87	N	Galioto
40	NES /6.1.1.4	2.4.2	In the event that the surveillance program indicates that a substantial margin against tube ruptures cannot be firmly substantiated, plans for replacing the current pressure tubes should be accelerated.	Current plans and design activities support pressure tube manufacturing with the first set of qualified tubes available at the end of CY88. Acceleration of this activity will gain 8 to 10 months; however, the additional schedule acceleration represents	an operability, not a nuclear safety issue, and hence was accorded a relatively low priority. The acceleration is not currently planned.	working		FY89	07/01/87	N	Galioto
46	NES /6.2.5	2.9.1	It is recommended that a formal EQ program be established for N Reactor for both electrical and mechanical safety related equipment. This development should be expedited. Include ECCS, HCR & Ball systems.	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	47,28	FY90	07/01/87	N	Foster
47	NES /6.2.5	2.9.1	It is recommended that a formal EQ program be established for N Reactor for both electrical and mechanical safety related equipment. This development should be expedited. Include confinement system, RHCS.	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	46,25,17	FY90	07/06/87	N	Foster

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52	DES /7.4	2.1.1	The necessary changes in the control room reported in UNI-2097 should be completed in a timely way and two potential problems should be addressed (I.B.1.)	Recommendations from UNI-2097 identified 28 design changes. All of the design and analyses have been completed and 2 design changes remain to be installed. These design changes will be reviewed in light of review team findings and incorporated in FY87.		working	105	4Q87	07/01/87	*	Pyzel
57	DES /7.4	2.3.6	Prevent contamination outside Zone I by systems in communication with the primary coolant system. (II.B.2 and (III.B.1.1)	A previous study will have updated, expanded and resulting recommendations will be implemented.		working		FY89	07/01/87	*	Schmidt
60	DES /9.13.2	2.3.4	The procedures used to ensure that the confinement pressure sensing block valves are open should be reviewed.	The EMG that calibrates the confinement pressure switches has a deliberate return to normal procedure, including action to lock wire the block valves in the open position. Consideration will be given, during the current review of the adequacy of MCL's	(Mandatory Check Lists for reactor startup), to include a signed verification of block valve position before each reactor startup. The need for additional physical access controls will also be considered.	working		2Q87	07/01/87		Schmidt
82	TSA /AE.5	2.1.2	Update the battery maintenance program to meet current industry practices.	This program is part of the EMG system and is being upgraded to meet IEEE guidelines.		working		2Q87	07/01/87		Pyzel
91	TSA /ER.6-1	2.1.1	Establish alternate evacuation routes from the N Reactor building and support facilities. Clearly mark evacuation routes.	Alternative actions will be stated in N Reactor evacuation procedure.		working		4Q87	07/01/87	*	Pyzel
101	TSA /OP.1	2.1.1	Improve shift supervisor and shift manager log entries to include times for each entry and to include sufficient information on events which are off normal.			working		2Q87	07/01/87		Pyzel

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103	TSA /OP.3	2.1.1	Improve the tag and lockout system to assure the correctness and presence of old tags and also improve the feedback portion of the system which updates the tag logbook when tags are removed.	Full transition to the new computer based L/T system will be completed by end of 3rd quarter FY87 including personnel training.		working		3Q87	07/01/87		Pysel
121	TSA /OP.4	2.1.2	Take the initiative to expand DWC responsibility realignments to provide all radiological protection program features for construction personnel at H Reactor.	AAJ was a DOE contractor, thus obligated to maintain a radiation control program for construction work. Since UNC is responsible for overall radiation control at its facilities, Radiological Engineering is currently investigating methods of improving	the established system to ensure personnel receive the benefits of a high quality protection program while working at UNC controlled facilities.	working		FY88	07/01/87	Y	Pysel
120	TSA /TS.3	2.1.1	Enforce the time limits for Temporary Plant Modifications.	A revised Temporary Change Notice procedure was issued in October 1986.		working	97	1Q87	07/01/87		Pysel
131	TSA /TS.6	2.1.1	Develop a more comprehensive waste generation reduction program including specific goals for hazardous and radioactive components.	Project B-773, H Area Radioactive Solid Waste Handling Facility, is currently funded as a FY87 GPP. A comprehensive waste generation reduction program with specific goals will be implemented.		working		2Q87	07/01/87		Pysel
136	/	2.4.3	Perform graphite surveillance analysis and modeling.	Will provide updated analysis of graphite to project future trends and distortion conditions. Additional pile motion monitors to be installed		working		FY91	07/01/87		Ballato

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137	/	2.4.3	Analyze graphite distortion consequences.	Will provide updated analysis of graphite to project future trends and distortion conditions. Additional pile motion monitors to be installed.		working		FY91	07/01/87		Galioto
140	DOE /R5	2.2.1	Provide for hydrogen control by inerting Zone One of the confinement system during power operation.	See discussion on related item.		working	56		07/01/87		Franz
147	DOE /R17	2.4.3	Graphite growth in the stack is beginning to reverse from a long period of growth (approaching maximum of 2 inches by about 1989-1990).	Enhanced surveillance and analysis underway and will continue.		working	137,138		07/01/87		Galioto
152	DOE /LT2	2.2.1	Hydrogen igniters should be installed.	See discussion on related item.		working	56		07/01/87		Franz
155	DOE /LT5	2.4.2	Intensification of process tube monitoring is endorsed.	See related items.			36,37		07/01/87		Galioto
159	DOE /LT10	2.5.4	Coolant bleed-off discharge to the ground should be discontinued.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	3		07/01/87		Blankenship
160	DOE /LT11	2.5.4	An alternate plan for handling accident waste water is needed.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working			07/01/87		Blankenship
162	DOE /LS3.	2.1.1	Unable to understand the management structure, top to bottom, that envelops the N Reactor, and believe the line of responsibility to be too long and too tenuous.	Significant internal UNC reorganization has been accomplished to address the accelerated work items efficiently and expeditiously. The organizational structure will be reviewed by the new O & E contractor during the transition.		working			07/01/87		Pyzel

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166	ROD /T3	2.2.1	Re-evaluate the generation and control of hydrogen under accident conditions. Investigate the methods of prevention of build-up of explosive mixtures and detonation, for example, controlled burning, recombiners, inerting.	See discussion on related item.		working	56		07/01/87		Franz
168	ROD /T5	2.9.1	Analyze and test each component and sub-system of the confinement system to the maximum extent feasible to ensure its proper operation	The equipment qualification program is a multi-year program started near the end of FY86. FY87 activities will accelerate the total plan two years based upon commercial nuclear requirements being applied to N Reactor. Early testing and analysis on key	components will be completed by July 1987. Identification of the basis for equipment lists and the seismic and environmental conditions will be in the revised plan for accelerated qualification issued by July 1987.	working	25,67,88		07/01/87		Kester
172	ROD /T9	2.4	Maintain a vigorous surveillance and replacement program, especially with regard to process tube failure and graphite growth.			working	14,37,134,137		07/01/87		Ballato
179	ROD /H8	2.2.1	Potential hydrogen generation a N Reactor is greater that that at Chernobyl and other commercial reactors. Hydrogen mitigation should be provided. Evaluate hydrogen generation and distribution under various inerting and/or provide igniters.	See discussion on related item.		working	56		07/01/87		Franz
181	ROD /H10	2.5.3	Stop primary coolant discharge to the surrounding soil. An ion exchange system is needed to purify primary coolant. In the event of a severe accident, a method to contain the waste water until it can be decontaminated is needed.	99% of the 1000 off-site dose is due to Sr90. The major source is from exposed fuel in the 105N basin. Fuel damage arrestor and cleanup of the fuel basin will reduce the Sr90 source.		working	168		07/01/87		Blankenship

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188	ROD /P3	2.2.1	Install a hydrogen-mitigation system for confinement. Calculate the local concentrations of hydrogen in confinement compartments during an accident,include effects of large amounts/rates of release,and the different locations of release to aid in design.	See discussion on related item.		working	56		07/01/87		Franz
189	ROD /P4	2.5.4	Install a confined basin or tank to contain highly radioactive liquids that will be pumped from the confinement during an accident.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	160		07/01/87		Blankenship
202	ROD /P20	2.2.1	Containments and confinements need to be protected against hydrogen explosion or detonation.	See discussion on related item.		working	29,56		07/01/87		Franz
204	ROD /P22	2.2.1	Issues considered are hydrogen explosion, the adequacy of the radioactive removal design, potential danger of storing accident-generated radioactive liquids in the crib, adequacy of information available to train operators in emergency procedures.	See discussion in item 56 for hydrogen issue. The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.		working	56		07/01/87		Franz
206	ROD /P24	2.2.1	Uncertainties in the containment hydrogen issues are unacceptable and should be resolved with highest priority - no reason to wait for PRA completion.	See discussion on related item.		working	56		07/01/87		Franz

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287	ROD /P25	2.2.2	The N Rx confinement could not survive the pressure increase if an appreciable quantity of hydrogen were to explode, deflagrate or detonate. Exhaust filters are especially vulnerable.	See discussion on related item.		working	29		07/01/87		Franz
215	ROD /P34	2.5.4	Installation of a closed vessel or tank to contain the radioactive liquid pumped to the crib is recommended. Similar consideration should be given to the liquids that are normally bleed and leak from the primary coolant system.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system.			160		07/01/87		Blankenship
223	ROD /P38	2.5.4	N Rx does not operate within the risk level concluded in the 1978 safety study because of risk of contamination ground and surface water from radioactive liquids produced in a severe accident and pumped to a crib outside the confinement.	The 1312N basin will be lined to contain high level effluent from an accident. The unused 1301N crib will be disconnected from the system. PRA will resolve.			160		07/01/87		Blankenship
9	DES /4.3.3	2.6.2	Accident analyses should be performed to determine the effect of pressurizing confinement at a time when significant quantities of fission products are present.	The subject analyses will be performed using upgraded analysis tools (see 022) in support of the Level 2 PRA.		working		4Q87	09/30/87		Guapp
19	DES /5.7	2.6.2	Blockage of pressure tubes by fuel failures should continue to be considered in the evaluation of severe accidents.	The Level 1 PRA analytical support will include evaluation of pressure tube blockage events, including blockage due to fuel failure. This evaluation will be completed in FY87.		working	64	FY88	09/30/87	x	Guapp

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32	DES /5.7	2.8.3	The pressure tube flow monitoring system should be evaluated to determine if a better, more available instrument exists.	Currently the system has been upgraded by replacing aging capacitors, correction of workmanship deficiencies, and upgrading test methods and procedures. Further upgrades are in planning.		working		FY91	09/30/87		NA
34	DES /5.7	2.6	Formal LOCA analysis in conjunction with selected check valve failures should be conducted using new codes and results of the PRA.	LOCA analysis with check valve failure will be evaluated with upgraded analytical tools (see #22) in support of the Level 1 PRA.		working	64	FY88	09/30/87	*	Gnapp
53	DES /7.4	2.1.4	Upgrade safety parameter display. (I.D.2)	An Engineering Study will be completed in 4th quarter FY87 to re-evaluate the feasibility of using the ERIS/LAN system as an SPDS. The scope of follow on activities will be determined by the Engineering Study.		working	55	FY89	09/30/87		NA
61	DES /7.4	2.6.3	Evaluate reliability of decay heat removal methods. (II.E.1.1)			working	78	4Q87	09/30/87		Gnapp
62	DES /8.2.3	2.6	The hypothetical accident analyzed in NUSAR appears potentially to be a candidate for assessment in the PRA effort discussed elsewhere. If it is shown to be a risk dominant sequence, it should be re-analyzed, using current source term methodology...	The subject transient will be analyzed with upgraded codes in support of the Level 1 PRA.		working	64	4Q87	09/30/87		Gnapp
64	DES /8.7	2.6.3	Risk-dominant severe accident sequences, determined by the PRA, should be analyzed using current best-estimate models.	Upgraded state-of-the-art, best-estimate codes will be developed for N Reactor analysis (see #22) and used for analysis support of the PRA.		working		FY88	09/30/87	*	Gnapp

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69	DES /V.15.3	2.6.3	The undergoing Probabilistic Risk Assessment (PRA) should include common mode failures, including component failures and/or administrative control failure of the safety system bypass switches.	See recommendation # 78 - SSR/V.A3		working	78	4Q87	09/30/87		Bupp
78	SSR /V.A3	2.6.3	The Team recommends that the probabilistic risk assessment that has been initiated by UNC-NI be completed as soon as possible. It should be used to verify that challenges to the confinement system have been comprehensively encompassed, and once completed	A detailed task-by-task schedule and cost estimate has been developed to accelerate and expand the Level I PRA in response to Recommendations # 69 and # 78. The budget associated with these recommendations includes the incremental costs: to advance the	completion of the Level I PRA by one year, to expand its scope to include Level 2 integration (see 84), common-mode failure analysis, additional confinement analyses, and internal fire and flood analysis and to provide liaison with the LANL Level I PRA.	working		4Q87	09/30/87		Bupp
88	TSA /ER.4-1	2.8.4	Upgrade emergency response capability of the N Reactor control room, emergency control center, and alternate emergency control center. (Does not include # 87)	An engineering study to evaluate options for near-term emergency response facilities upgrades will be complete in April 1987 and upgrades completed by September 1987.		working	87	FY91	09/30/87	*	Dugan
99	TSA /OA.2	2.1.2	Provide a tracking system to facilitate management's ability to measure progress toward achieving objectives cited in the Long Range Plan.	A revised commitment tracking system is being developed with implementation expected in FY87.		working		FY88	09/30/87	*	Pyzel
106	TSA /OP.7-2	2.8.3	Reduce work area temperatures in building 109-N so as to provide longer working times for operators on hot days.	Project H-671, 109-N HVAC Upgrade (currently cancelled), will be re-evaluated for current justification. Re-evaluation to be completed by the end of FY87. If justified, funding will be requested for design in FY88.		on-hold		FY90	09/30/87		NA

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133	TSA /DES	2.10.11	Obtain independent certification of the adequacy of personnel qualification standards and training programs			working		FY88	09/30/87	*	Jones
143	NRD /R9	2.6	...The "N" Reactor design is such that an instantaneous postulated radioactivity release accident cannot be handled during the first pressure venting phase of the accident.	The confinement design is based on fuel failure characteristics for solid zirc clad metallic fuel without internal gas voids (all fission products are in solution within the metallic fuel matrix) such that no instantaneous release of radioactivity can	occur. This design assumption will be evaluated as part of the Level 1 PRA.		8		09/30/87		Knapp
144	NAD /R10	2.6.3	The present confinement design has real possibilities of resulting in air releases in case of unexpected accidents even after inerting Zone One.	Confinement behavior for a range of severe accidents will be evaluated with upgraded codes (see 022) in support of the Level 2 PRA.		working	192-195		09/30/87		Knapp
161	NRD /LT12	2.6.3	The consequences of really severe accidents are not included in NUSAR. Such accidents will be a part of the PRA. Those that can be identified now should be examined and analyzed at once without awaiting the completion of the somewhat slow PRA process.	Analysis of degraded core accidents will be initiated when the upgraded computer codes are available (see 022). Preliminary assessment of high frequency core melt sequences will be available at that time from the PRA and will be used as a basis for	evaluation.	working	4,16,69,70		09/30/87		Knapp
176	NAD /D4	2.10.11	Arrange for INPO assistance followed by accreditation reviews by INPO.	See related item.		working	133		09/30/87		Jones
194	NRD /P7	2.6.2	Perform a mass transfer analysis that does not rely on data on radioactivity-removal kinetics obtained when there is simultaneous condensation of steam.	The subject analysis will be performed with the upgraded analytical tools (CONTAIN see 022).			192		09/30/87		Knapp

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199	ROD /P16	2.6.2	Consider the possibility of slugs of water reaching the dry overheated fuel in horizontal channels in accidents involving overheated fuel and metal-water reactions. Also, consider the vertical channels in N Reactor for backup control absorbers.	Reflood of a hot dry core will be studied as part of the severe accident analysis effort.		working	191		09/30/87		Buapp
193	ROD /P7	2.6.2	Analyze a technical basis for the particle-size distribution of particulate radioactivity released to the confinement and transported to other compartments.	The expected particle size distribution will be analyzed with upgraded fission product transport codes (TRAP-MELT, CONTAIN) and application of available data. Sensitivity analyses will be performed with the upgraded codes for assumed particle sizes.		working	192		10/01/87		Buapp
212	ROD /P31	2.6.2	Information has not been provided to justify the design assumption that the particle size distribution released to the confinement is the same as the particle size used in the spray removal experiment.	A review of aerosol transport, agglomeration, attenuation in the primary system will be re-evaluated.			218		10/01/87		Buapp
45	DES /6.1.2.2	2.4.2	Methods should be developed to monitor stack distortions that are possible precursors to sudden offsets.	Activity must await completion of # 42 & 43.		working	36,42,43	4Q87	10/30/87		Baliato
44	DES /6.1.2.2	2.4.2	Tests of blocks and/or tubes should be performed if necessary to obtain reliable values.	Activity must await completion of # 42 & 43.		working	36,42,43	4Q87	12/31/87		Baliato
56	DES /7.4	2.2.1	Evaluate hydrogen control equipment. Add the best system unless it would increase the overall risk to public by causing fog sprays to be turned off. (II.D.7)	The Engineering Study has been accelerated. Design and installation of monitoring equipment is proceeding.		working		4Q87	12/31/87		Frame

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92	TSA /ER.6-2	2.1.1	Improve the capability to provide immediate aid in life-threatening situations by using trained shift personnel.	The UNC management position will be re-evaluated.		working		4Q87	12/31/87		Pyzel
149	RDD /R19	2.2.1	"N" reactor does not now have any hydrogen control systems. "N" does not have a hydrogen indicating system...though it has recently recommended that such instrumentation be installed.	See discussion on related item.		working	56		12/31/87		Franz
153	RDD /L13	2.2.1	It is important to provide the N Reactor with a means of preventing hydrogen explosions or of mitigating their effect to such a degree that the confiner will retain its integrity.	See discussion on related item.		working	56		12/31/87		Franz
186	RDD /N21	2.1.1	There is an apparent sense of complacency at many levels from the DOE staff on down through contractor operations that "it can't happen here" at the N Reactor.	Additional external review and overview services are being requested.			145		12/31/87		Pyzel
208	RDD /P27	2.6.2	There has been no functional test of the ability of the fog sprays to quench steam and remove radioactivity. Assurance of performance rests entirely on the design analysis.	Condensation rates and decontamination factors will be evaluated and documented. See # 214.			8,26,27,160,214		12/31/87		Quapp
209	RDD /P28	2.6.2	The only documented design analysis of the N Reactor spray system is that contained in the 1970 safety analysis report.	An updated design and performance report will be prepared.		working	22,66,78,79		12/31/87		Quapp

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210	ORO /P29	2.6.2	There are several reasons why H Reactor confinement sprays may not perform in the way predicted by the [illegible] analysis.	Updated analysis using current analytical methods will be conducted.		working	209,4,16,69		12/31/87		Guapp
211	ORO /P30	2.6.2	Elemental iodine is not expected to be present in the reactor during a severe accident as assumed in the safety analysis. Whether hydrogen iodine decomposes to elemental iodine in the confinement and the effect on spray removal has not been analyzed.	Fission product chemistry will be reviewed for postulated severe accidents in H Reactor. PRA studies will evaluate the influence of uncertainty of species on overall risk.		not started	210		12/31/87		Guapp
214	ORO /P33	2.6.2	It is recommended that the design analysis of the H Reactor fog spray system be reviewed by the group in the DuPont Engineering Service Division at Newark, Delaware.	External competent review of the design bases and decontamination factors used in the analysis will be performed.		not started	210		12/31/87		Guapp
222	ORO /P38	2.6.3	H Rx does not operate within the risk level concluded in the 1978 safety study because of technical uncertainties in the design of the confinement fog sprays to remove radioactivity released to the confinement.	Confinement fog spray efficiency will be re-evaluated. Technical bases for the decontamination factors will be supplied.		working	209,210		.12/31/87		Guapp
5	DES /4.2.3	7.8.2	The program to improve habitability aspects of the main control room should be expedited.	Project H-544, Control Room Habitability, is in Definitive Design. Construction is scheduled to start Jan 1987 and to be completed Mar 1988. 90 % completion is estimated by July 1987.		working		FY88	03/31/88		Degen

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23	DES /5.7	2.6.2	The best estimate capability should be aggressively used to search out the limits of N Reactor performance.	The analytical tools required to address operating and safety limits will be upgraded in FY87 and a full re-evaluation of operating and safety limits will be completed in FY88.		working		FY88	03/31/88		Baapp
33	DES /5.7	2.6.2	The calculation of the flow monitor set points should be evaluated based on best estimate models.	Flow monitor set points have been developed using experimental data for the specific N Reactor tube in tube fuel and pressure tube geometries. This experimental data base is applied to upgrade computer models and a re-evaluation of operating limits will	be completed in FY88.	not started	23	FY88	03/31/88		Baapp
77	DSM /IV.B3	2.6.4	The Team recommends that the reliability and availability of the gas inerting system as a safety related system be re-evaluated in view of its role in preventing fires/explosions and that new Technical Specifications should be established, if necessary.	The re-evaluation recommended will be implemented by performing a probabilistic risk assessment (PRA) and degraded core analyses including specific attention to the potential for inleakage of air into the reactor stack and the generation of hydrogen that	could be released to the stack. The results of these analyses will provide the bases for determining what upgrades are needed to improve the reliability/availability of the gas inerting system and/or modifications to the Technical Specifications.	not started		4Q87	03/31/88		NA
142	NAS /A4b	2.8	Provide protection and separate ventilation for the control room, or an alternate location, during accident conditions.	Provided by Project H-504, Control Room Habitability.		working	5		03/31/88		Bogen
182	NAS /A11	2.8	Certain modifications to design requirements have been endorsed by many reviewers, such as, remote shutdown capability, control room habitability, and backup emergency core cooling. Assign priority attention to their accomplishment.	See related serial #'s for discussion.		working	5,15,24,89		03/31/88		Bogen

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30	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include tests to determine whether there are any effects of high hydrogen and creep on defect growth in irradiated material...	Tests have been conducted to determine the effects of defects and hydrogen. Additional tubes are planned for removal and examination as noted in # 37. Tests will be performed to determine the effects of defects in irradiated material with hydrogen well	above current levels.The effects of Hydrogen on defect growth rate will be studied using archive material. Initial results will be available in FY87. Plans for NDE of reactor tubes will include tests for evidence of these effects.	working	36	4Q87	05/31/88		Galindo
30	DES /6.1.1.4	2.4.2	It is recommended that the surveillance program for pressure tubes be further enhanced to include : burst tests with tube material removed from the inlet, middle, and outlet regions of pressure tubes.	Burst tests were conducted in 1978. Burst testing will resume in FY87 as a standard part of testing tubes removed for examination. These tests will be conducted on material from tubes that have been removed for examination.		working	36	4Q87	05/31/88		Galindo
17	DES /5.7	2.0.1	The GSCS should be made a safety grade system. It's ability to function in a degraded condition over a long time should be assessed.	An Engineering Study to determine what is needed to make the piping and controls to a safety system and provide an additional water supply and a seismic analysis will be completed by July 1987 and a program will be established. Short-term actions to	upgrade the system will be complete by July 1987.	working		FY89	06/15/88	*	Bogan
10	DES /4.4.4	2.7.3	A flood hazard assessment should be undertaken to better understand the threat of flooding at the site.(DOE-HQ program).	DOE to establish completion date. Results to be evaluated in conjunction with Recommendation # 11.		working		FY88	07/31/88		RB
11	DES /4.4.4	2.7.3	A modern flood analysis is recommended.	A review of the DOE state-of-the-art flood assessment, including upstream dam failures, will be performed to determine whether additional studies are required to improve confidence in flood levels established in earlier studies by the Corps	of Engineers and Bureau of Reclamation. If required, new studies will be completed by the end of FY88. The results of these studies will be utilized to respond to recommendation # 13.	on-hold		FY88	07/31/88		RB

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13	DES /4.5.6	2.7.5	It is recommended that the 181-D building be evaluated for flood conditions identified in the studies proposed including dynamic wave effects.	An Engineering Analysis will be completed in FY88 using a modern flood analysis. (See Recommendation 011). Meanwhile, the evaluation is proceeding ona low priority basis.		working		FY88	07/31/88		[illegible]
217	DOD /P36	2.5.6	On-line sampling of the primary water coolant to monitor chemical conditions should be restored.						07/31/88		[illegible]
2	DES /4.2.3	2.5.6	Raise the sensitivity of detection of small coolant leaks commensurate with understandings developed above.	An engineering study on leak detection and prevention will be completed and a program (if required) will be established.		not started		FY89	09/30/88		[illegible]
54	DES /7.4	2.1.4	Determine whether post accident sampling of primary coolant would improve operator's ability to respond to the accident. (II.B.3)			working	58	FY88	09/30/88		[illegible]
58	DES /7.4	2.6.4	Upgrade instrumentation to evaluate severe accidents. (II.F.1 and II.F.3)	An Engineering Study to determine instrumentation required to evaluate severe accidents will be conducted as information from the PRA becomes available. Upgrades to the instrumentation will be incorporated in FY88.		not started		FY90	09/30/88		[illegible]
66	DES /8.7	2.6.1	Experimental programs should be performed to provide data for analysis. This includes kinetics of dissolution of zircaloy by molten uranium and fission product release from fuel.	Initial efforts in FY87 will be to perform limited evaluations on uranium-zirc alloys, to develop experimental data base requirements, and to perform detailed program planning for FY88 and FY89.		working		FY89	09/30/88	*	Knapp

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125	TSA /TC.7-1	2.10.10	Upgrade the N Reactor system training manual (UNI-N-94) to provide current information important to plant operators including system operation characteristics, system interrelationships, and abnormal operations.	UNI-N-94 is kept up-to-date, but needs to be rewritten to provide the necessary detail to be utilized as an official study guide.		working		FY88	09/30/88		Jones
4	NAS /4.2.3	2.6.3	The probabilistic risk assessment programs that are currently envisioned should be upgraded to level 3.	UNC's Safety and Reliability Evaluation Program is being accelerated and expanded to provide the Level 1 analysis required to support completion of a full-scope Level 1 PRA by the end of FY87 (see Q 78). Analytical tools essential to the Level 2/3 phases	of the PRA are being developed (see Q 71). The FY87 budget request for the Level 2/3 program provides for development of a detailed management and work plan, completion of plant familiarization, and performance of accident progressions analyses.	working		FY88	12/31/88		Knapp
16	NAS /5.7	2.6.3	A full scope level three PRA should be performed for the N Reactor.	See recommendation # 4 - NAS/4.2.3/003.		working	4	FY88	12/31/88		Knapp
130	ROD /R1	2.6.3	Radiological consequences of a severe reactor accident at the N Reactor would exceed the dose guidelines now used for licensed commercial reactors.	See related items.		working	4,23,62,64		12/31/88		Knapp
150	ROD /R20	2.6.3	N reactor meets or exceeds 40 of 55 General Design Criteria established by Appendix A to 10 CFR 50 (UNSAR vol 2). It doesn't meet 6, partially meets 1, and meets the intent of 8. Doesn't meet Appendix E (fission product release) & Appendix R (circuit sep)	The General Design Criteria were developed specifically for standard commercial PWR and BWR Reactors, therefore, are not directly applicable to N Reactor. The application of each design criteria is discussed in detail in the UNSAR. Those	specific cases where the consultants questioned the UNSAR analysis are being addressed in the appropriate consultants recommendations, e.g., 140,141,144, etc.	working			12/31/88		Knapp

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163	ROD /LS5	2.6	The N Reactor confinement system should be evaluated in a Level 3 PRA to verify its premise (release of steam and radioactivity would be sufficiently separated in time to allow valves to close after steam release).	See serial # 143 for discussion.		working	4,16,69,70		12/31/88		Gaupp
191	ROD /P6	2.6.3	Extend the safety analyses to include accidents that develop higher fuel temps,greater quantities of hydrogen at greater rates, and evolve fission products in different chemical forms, and include accidents involving equipment failure and operator error.	Degraded core accidents more severe than the [illegible] hypothetical accident will be analyzed as part of the Level 2 PRA (see 8161).Accidents involving operator errors will be evaluated as part of the Level 1 PRA.		working	22,66,79,56		12/31/88		Gaupp
219	ROD /P30	2.6.3	N Rx does not operate within the risk level concluded in the 1978 safety study because of technical uncertainty in the production of hydrogen in severe accidents.	This question is being completely reviewed. Updated analytical models are being developed. PRA will guide the analysis and the highest frequency accidents will be completely analyzed.			56,77,146		12/31/88		Gaupp
224	ROD /P40	2.6.3	The N Rx can be operated within the risk levels found in the 1978 safety analysis report if the uncertainties in that report, as identified herein are resolved.	Revised and expanded analyses will be conducted in support of the PRA.			209,216,218-222		12/31/88		Gaupp
226	ROD /LS2	2.6.3	It is important for quality control, that the PRA also be subjected to peer review, outside the DOE family.	A competent peer review panel is being formed and will be used to verify the quality of the PRA process.		working			12/31/88		Gaupp

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229	NOB /N16	2.6.3	The N Reactor is not as safe as our US commercial plants. It should be recognized by the DOE that it does not meet all present-day standards for commercial reactors.	The PRA will quantify relative safety.		working	4,16,23,62,158		12/31/88		Knapp
24	DES /5.7	2.7.4	An alternate ECCS project should be implemented.	Project H-766, Alternate ECCS Supply, an FY89 Line Item, was initiated prior to Chernobyl. A preliminary rescoping evaluation has been completed and is being documented in an engineering study. Conceptual effects on this project are being accelerated to	permit initiation of definitive design in 1st quarter FY88 subject to DOE funding availability. Accelerated completion date is subject to funding availability.	working		FY92	06/01/89	*	Kelly
185	TSA /OP.7-1	2.1.4	Improve the control room annunciation systems.	An engineering study will be completed in FY88 to identify appropriate human factors criteria to be applied to the 105-N Control Room. Preliminary Design and procurement will be initiated in FY88 with estimated completion in FY89.		working		FY89	09/30/89		RR
15	DES /1.5.6	2.7.1	The UNC program to provide an alternative source of water for the N-Reactor ECCS should be expedited.	Due to the long lead time required for a true alternate ECCS, a near-term project has been initiated to supplement the ECCS supply until the long-term project is complete. The FDC and engineering study for the Supplemental ECCS were provided to DOE for	approval/information respectively, in Jan 1987. Definitive design has been initiated, but is on-hold pending a system re-evaluation.	on-hold		FY88	/ /		Kelly
141	OOO /86a	2.7	Providing better physical separation for the redundant emergency water pumping systems and water supplies for the ECCS and the GSCS.	See serial # 15, 21 and 24 for discussion of actions.		on-hold	15,21,24		/ /		Kelly

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151	NOB /LTI	2.7	Backup emergency core cooling project should be completed.	See related serial #'s for discussion.		on-hold	15,24,21,182		/ /		Kelly

PREPARED QUESTIONS SUBMITTED BY SENATOR HATFIELD

Senator HATFIELD. Mr. Chairman, I am sorry to take so long and I appreciate it. I do have some written questions I would like to submit for the record to follow up.

Senator JOHNSTON. Very well.

[The questions and answers follow:]

QUESTIONS SUBMITTED BY SENATOR HATFIELD

Hanford N Reactor

Question: The Department's safety review and the Roddis Panel of independent consultants provided some 130 safety and environmental recommendations for the reactor. Do you plan to implement these recommendations?

Answer: Since the Chernobyl accident, N Reactor has had five independent reviews and the Roddis Panel review. There were 133 recommendations prior to the Roddis report. The Roddis report increased the number of recommendations for resolution to 228. The Roddis report reinforced the previous recommendations and added emphasis and urgency to their resolution. We plan a resolution to each recommendation as part of the overall Safety Enhancement Program, and the ongoing environmental and operations upgrade programs.

Question: In January, the Secretary announced that the reactor would be temporarily closed for 6 months until July, "to accelerate previously planned improvements and to expand them to include additional recommendations." What is the total cost of improvements in FY 1987?

Answer: The Department will expend about $122 million through FY 1989 to complete the N Reactor safety enhancement effort. This effort includes the costs of scheduled safety work as well as accelerated safety enhancements that were recommended by DOE and private consultants to be completed during the 6-month stand-down period. The costs to complete the planned FY 1987 phase of this program is $50 million; however, some portions of the overall effort may be accelerated because of congressional and Department of Defense interest in bringing the N Reactor back into operation as planned. These accelerated efforts would cause the efforts for the FY 1987 phase of the program to increase somewhat with a corresponding decrease in FY 1988 and FY 1989.

Question: How much of the funding for FY 1987 improvements is for previously planned work and how much is for new recommendations?

Answer: In FY 1987 Congress provided an additional $20 million for implementation of the 51 recommendations presented in the Department's safety review of N Reactor. The President's FY 1987 budget request included funding for N Reactor maintenance and reactor safety work which has also been identified as part of the Safety Enhancement Program. Some of the work identified by the reactor review teams was work which would have been completed in the original scheduled outage for N Reactor. The reactor standdown merely extends the original outage.

Approximately $32 million in FY 1987 was for previously planned work and approximately $18 million is earmarked for new recommendations and acceleration of previously planned work.

Question: How much is the total estimated cost for all the improvements recommended by the review panels?

Answer: The overall Safety Enhancement Program requirement amounts to approximately $122 million. This total cannot be divided among the various review groups because of the substantial amount of duplication among the recommendations.

Question: When would these safety and environmental improvements be completed?

Answer: Most safety and environmental improvements will be completed before 1990.

Question: I understand that the hydrogen gas control or mitigation system recommended by Chairman Roddis could not be completed until December 1987. Is this correct?

Answer: The Hydrogen Monitoring System will be completed during the standdown period. The Hydrogen Mitigation System will be partially completed during the standdown and will be completed during the scheduled December outage. The National Academy of Sciences has been requested to review the Department's technical and managerial approach to resolution of the hydrogen mitigation issue as part of their review of N Reactor.

Question: I am advised that the recommendation which would eliminate the release of radioactive primary coolant water into the soil at Hanford would cost about $100 million and take over a year to complete. Is this correct? Is this improvement cost-effective?

Answer: It was originally estimated that it would cost $79.5 million to eliminate the routine discharge of N Reactor primary coolant water to the soil. We have, however, been able to reduce this figure to $41.3 million through value engineering.

The work has also been divided into three distinct budget packages to provide a clearer cost-benefit decision structure.

The first of these packages consist of $1.3 million of operating flow reduction measures. These improvements alone reduce radionuclide releases by approximately 52 percent. Such gains are clearly cost-beneficial and are being undertaken using FY 1987 monies.

Package number two is a $15 million Radioactive Liquid Effluent Facility (project 87-D-150). Work on this project is currently limited to design only. If funded to completion, it will provide high efficiency filters to remove radioactive particulates from the waste water. This will reduce discharges by another 23 percent (a 75 percent cumulative reduction).

Package number three will consist of a supplemental ion exchange module for the effluent treatment facility. This module can effectively reduce discharges to zero but will cost $25.0 million. A decision has not yet been made as to whether the Department will seek funding to add it in FY 1989. Given the fact that N Reactor will only operate until 1995, the useful life of the module would be relatively short.

Question: Are you providing better separation for the redundant emergency water pumping systems and water supply as recommended by Chairman Roddis? If so, when will this be completed and at what estimated cost?

Answer: A number of actions are being taken to ensure that an adequate quantity of cooling water is available to remove residual heat from the reactor core under all possible accident conditions.

The first of these actions involves the construction of walls between the emergency core cooling system, ECCS, pumps. This a low cost improvement and work is already underway. Better physical separation of the pumps will reduce the possibility of simultaneous damage in the event of a diesel drive fire.

Work has also begun on a new supplemental water supply for the ECCS. This supplemental system will cost approximately $1.4 million and, when completed in December 1987, will provide adequate water for seven days of ECCS operation.

Finally, we are exploring the merit of adding a second, or alternate, ECCS for the reactor. Initial estimates indicate that such a system would cost in excess of $8.0 million. If undertaken, it would be funded as a FY 1989 construction line item and will require approximately 2½ years to complete.

Question: If you begin operation of the N Reactor in July, as planned, I understand that the planned EIS will not be complete and the planned safety improvements will be only 50-60 percent complete. Is that an accurate assessment?

Answer: The Environmental Impact Statement, whose scope is the Safety Enhancement Program, will not be completed by restart, since this is a 2 year process. One hundred sixty of the planned safety improvements will be completed. This is 70 percent of the requirements/recommendations. A smaller percent, about 55 percent, of the cost of the program will be incurred prior to restart, since the high-cost projects are in FY 1988 and FY 1989.

Question: In May 1986, shortly after the Chernobyl accident, the Secretary asked the National Academy of Sciences (NAS) to assess the safety of DOE defense reactors. As a result of your recent agreement with certain House members, as I understand it, the Department now agrees to carry out any recommendations made by NAS including running the reactor after July at lower power levels. Is there anything else or any other features of this agreement?

Answer: The Department of Energy is currently working with the National Academy of Science/National Academy of Engineering to finalize the scope of their review of hydrogen mitigation for N Reactor. The Department has no intention of expanding the scope of this activity to other areas or issues.

Question: I am advised that DOE has terminated life extension beyond the mid-1990's for the N Reactor. In your view, how much longer can DOE run the N Reactor at previous power levels?

Answer: N Reactor can continue to operate to approximately 1995 at the full power level with normal, planned maintenance activities. The life of the reactor is a function of reactor operating time and power level. Therefore, if extensive outages and/or reductions in power occur in the future, the date for end of reactor life would be correspondingly extended.

Question: What is the current annual operating budget for the N Reactor?

Answer: The current annual operating budget for N Reactor is about $200 million. This does not include supporting services, capital equipment, and construction expenses. The total FY 1987 budget for United Nuclear Corporation, which operates N Reactor for the Department, was $238.4 million.

Question: At reduced power levels by 25 percent, would there be any savings of operating costs? At 50 percent lower power?

Answer: Very minor savings in fuel fabrication costs and consumables could be realized by reducing the power level by 25 or 50 percent. Annual operating costs would be essentially unchanged since full operating crews are required to operate the plant safely at any power level.

Question: What is the estimated change in annual production output in metric tons at these lower power levels?

Answer: The production output of the Richland N Reactor varies with power level. At 50 percent of full power, the Richland N Reactor would produce about DELETED percent of the weapon-grade plutonium produced at full power. At 75 percent of full power, about DELETED percent of the full power production would be realized.

Plutonium Supply

Question: How much plutonium is in the stockpile?

Answer: As of September 30, 1986, the Department of Defense Finished Weapons Stockpile contained DELETED metric tons of weapon-grade plutonium.

Question: Does this figure include the plutonium scrap material? How much of that is available?

Answer: The Department of Defense Finished Weapons Stockpile does not include scrap material. As of September 30, 1986, the Department of Energy weapons program inventory contained DELETED metric tons of nonspecification plutonium. The nonspecification plutonium must be processed to remove impurities before it can be used for weapons builds. Much of this material is in a form which requires special processes and/or processing capacity which are limited or not available. Therefore, our progress in working-off this backlog, although positive, is limited.

Question: How much plutonium is produced annually at each of the production reactors in round figures?

Answer: The Department of Energy production reactors are scheduled to meet tritium requirements first. Those reactors not producing tritium are used to produce plutonium. In a plutonium production mode, when operating at full power, the Savannah River Plant P Reactor and K Reactor can each produce DELETED metric tons per year of high purity plutonium, and the Savannah River Plant L Reactor can produce DELETED metric tons per year of high purity plutonium. When the high purity material is blended with fuel grade material, P and K Reactors' output provides DELETED metric tons per year of weapons grade material and L Reactor output would provide a DELETED metric tons of weapons grade material. When operating at full power, the Richland N Reactor can produce DELETED metric tons per year of weapon-grade plutonium.

Question: The material from your Nuclear Weapons Stockpile Memorandum

DELETED

Answer: Each year the President approves the Nuclear Weapons Stockpile Memorandum via a National Security Decision Directive.

DELETED

Question: House testimony and recent briefings indicate that without N Reactor production, there is enough plutonium to meet your warhead projections DELETED . Is this correct?

DELETED

Answer: If N Reactor is not restarted and the Savannah River reactors are brought back to full power on the currently planned schedule, and the demands for tritium and plutonium do not vary significantly from present forecasts, then our current production planning cases indicate that we will meet warhead projections DELETED . It must be recognized that our production planning is based on cumulative production through the planning period.

DELETED

Question: Your graph

DELETED

Answer:

DELETED

Fiscal Year	Metric Tons Plutonium
1991	
1992	
1993	DELETED
1994	
1995	

Question: The graph also shows a substantial surplus of plutonium after DELETED. What is the amount in metric tons of the surplus each year through 2005?

Answer: With N Reactor operating, the plutonium surplus in metric tons of plutonium, as shown on the chart dated March 30, 1987, are given below. In reality, the reactors would be operated only at the level necessary

DELETED

Fiscal Year	Metric Tons Plutonium
DELETED	DELETED

The Nuclear Weapons Stockpile Memorandum material requirements projection are extended only through FY 1997.

Question: Explain the upgrade and restoration program at the Savannah River (SR) plant with a funding profile over the last 7 years.

Answer: A five phase construction project titled "Restoration of Production Capabilities" was initiated in FY 1981 to help offset the growing problems of plant aging and obsolescence. The total estimated cost of this project is $462 million. Approximately 80 percent of the cost is for work at Savannah River. All but eight of the upgrades have been completed. Construction is still in progress on the following:

- o Reactor Fuel Handling Improvements;
- o Production Components Replacement;
- o Production Support Equipment and Systems Replacement;
- o Primary Heat Exchanger Replacement;
- o Renovation of High Voltage Transmission System Control and Monitoring;

- o Powerhouse Coal Handling Facilities;
- o JB-Line Restoration; and
- o Warm Canyon Cranes.

Funding profiles for the Savannah River portions of the upgrade and restoration program are as follows:

Restoration of Production Capabilities - Savannah River
(Millions of Dollars)

Element	TEC	81	82	83	84	85	86	87	88	89
CAPITAL										
- Prj. 81-D-128	49.8	24.7	10.0	15.1						
- Prj. 82-D-124	300.2	-	36.0	61.3	69.2	72.3	38.5	3.9	13.2	5.9
CAP. FUNDS TOTL.	350.0	24.7	46.0	76.4	69.2	72.3	38.5	3.9	13.2	5.9
OPER. FUNDS	27.0	0.0	4.2	10.3	8.6	3.9	0.0	0.0	0.0	

Question: Describe the activities to increase the productivity of the SR reactors?

Answer: Studies have shown that the productivity of the Savannah River reactors could be increased by utilizing more productive designs for targets and fuel. The current production quantities of plutonium could be increased DELETED if a newly designed charge was implemented. However, the very high cost of the additional enriched uranium, more than $1 billion, for this charge does not make this option attractive at this time.

Question: Do you know of any life limiting mechanism at the three operating SR reactors? What is their life expectancy?

Answer: There are no currently identified reactor life limiting mechanisms at the three operating Savannah River reactors. However, based on recent developments, it is clear that should cracks appear in the tanks of these reactors, there does not currently exist a method to repair such cracks. The reactors at Savannah River should operate well into the next century.

Question: Describe the National Academy of Sciences concern over power levels at SR.

Answer: The National Academy of Sciences stated their concerns as "...we are not able to conclude with confidence that significant core damage would be avoided if there were a severe loss of coolant accident while the reactors are operating at the currently established reduced power limits." Since this concern was expressed, the power levels of the Savannah River reactors were reduced further.

Question: Do you expect lower power levels to continue at SR? For how long?

Answer: The reduced power levels will continue for at least the next 3 months. During that time experiments and calculations will be conducted to determine the extent to which the power levels can be increased. Return to original power levels may require up to 18 months.

Question: What is the impact on plutonium production at 25 percent or 50 percent reduced power levels?

Answer: Annual plutonium production is dependent on reactor operating power levels. For operation at 50 percent of full power the annual plutonium production would be about DELETED percent of the full power level per year for the Savannah River Plant reactors. At 75 percent of full power, the annual plutonium production would be about DELETED percent of the full power level.

Warhead Production

Question: Please provide for the record a table showing the breakdown of every warhead system included in the NWSM projections for each of the next 10 years, the projected number of each warhead produced each year, the amount of plutonium in metric tons required for each type of warhead or bomb each year, and the total amount of plutonium required for each warhead system.

Answer: The following table reflects the projected number of warheads to be produced yearly for the next 10 years.

PROJECTED NUMBER OF WARHEADS TO BE PRODUCED

FISCAL YEAR	STRATEGIC OFFENSIVE	THEATER	FLEET	TOTAL
1987				
1988				
1989				
1990				
1991				
1992			DELETED	
1993				
1994				
1995				
1996				
1997				

The following table shows the projected plutonium requirements for the projected number of warheads to be produced yearly over the next 10 years.

PROJECTED PLUTONIUM REQUIREMENTS FOR SCHEDULED PRODUCTION (IN METRIC TONS)

FISCAL YEAR	STRATEGIC OFFENSIVE	THEATER	FLEET	TOTAL
1987				
1988				
1989				
1990				
1991				
1992		DELETED		
1993				
1994				
1995				
1996				
1997				

Retirements

Question: There appears to be a troubling trend in the retirement of older warheads. From FY 1980-FY 1982, weapons-grade plutonium recovered from retirements

DELETED

. In light of these figures, Mr. Chairman, I would like to request a report from the Department of Defense on retirements. In addition, I request a table showing all stockpiled weapons described by number and name scheduled for retirement for each year from FY 1982 through FY 2005, the number of weapons scheduled for retirement each year, and the amount of plutonium in metric tons which will be recovered from each weapon system.

Answer: The plutonium recovered from retirements is a function of the number and type of warheads being retired each year. In general all but a few percent of the plutonium in retired weapons is recovered and used in new builds. As with plutonium required for new builds, retirements in some years are higher than others. Over the 16 year period from FY 1982-FY 1997, shown in the table below, retirements are expected to average approximately

DELETED

. The projection stops with FY 1997 because that is the last year for which we have a coordinated Department of Energy/ Department of Defense stockpile projection.

NUMBER OF RETIRED WARHEADS WHICH CONTAIN PLUTONIUM
FY 1982-FY 1986 ACTUALS -- FY 1987-FY 1997 PROJECTED

FISCAL YEAR	STRATEGIC OFFENSIVE	STRATEGIC DEFENSIVE	THEATER	FLEET	TOTAL
1982					
1983					
1984					
1985					
1986					
1987					
1988		DELETED			
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					

PLUTONIUM RETURNED IN RETIRED WARHEADS
FY 1982-FY 1986 ACTUALS -- FY 1987-FY 1997 PROJECTED
(IN METRIC TONS)

FISCAL YEAR	STRATEGIC OFFENSIVE	STRATEGIC DEFENSIVE	THEATER	FLEET	TOTAL
1982					
1983					
1984					
1985					
1986					
1987					
1988		DELETED			
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					

Tritium Shortage

Question: Admiral Foley, you indicate on page 4 of your statement that a shortage of tritium could prevent the Department from meeting weapons delivery schedules. If weapons delivery is stretched out, then I assume this will also reduce or stretch out plutonium needs. Can you indicate how this will affect your plutonium projections?

Answer: The tritium shortage I referred to in my statement is more of a concern, at this point in time, than an actual shortage. We are analyzing the situation, quantifying the impacts, and investigating ways to manage the demand so that there will not be any impact on weapons deliveries.

DELETED

. Consequently, we are not making any adjustment to our plutonium needs at this time.

NEED FOR REPLACEMENT REACTORS

Senator McClure. Mr. Chairman, I have a number of questions that I want to submit, a couple of rather general ones that look not just at where we are, but where we are going.

Back in the late 1970's and the early 1980's we had a number of studies that indicated we were going to have to build some more production facilities, and the N replacement production reactor was being decided on. And Secretary Hodel designated the Idaho site as a preferred site. And presumably an EIS would be drawn, and then we would go forward with that. And then the decision was made not to go forward with the NPR. But a change from a replacement production reactor, an RPR to a new production reactor, NPR, is a matter of semantics more than anything else. But a decision was made to stop. Why was that decision made?

Mr. Meinhardt. Well, I think it was made for two different reasons, one of which was that the Congress, very frankly, was not quite as forthcoming with the resources that would have been necessary to sustain the program. And I would just suggest that that is more on the House side than on the Senate side and we could leave it go at that if you will.

The other thing was that we recognized that in the then approaching constrained budgets that we were going to be operating in, particularly the Gramm-Rudman world, that there were not enough resources within our program to sustain the deployment of a new production reactor.

We, at that time, decided that we would look for a strategy that we could afford. And the one that we could afford was the refurbishment of N Reactor, which we called the Production Assurance Program. That obviously was a very viable strategy until something called Chernobyl happened. And so we had to abandon that.

There was also an issue with Secretary Hodel because he made the statement that he did. He had an intervenor lawsuit as a result of making the statement regarding Idaho prior to the completion of the National Environmental Policy Act procedure, the EIS, et cetera.

So there were several different factors that caused us to abandon the new production reactor strategy.

Senator McClure. It is pretty hard to do an EIS until you have made a site selection though, isn't it?

Mr. Meinhardt. Sir, by law, you must do the EIS in order to make that site selection.

Senator McClure. And then you must do another one afterward. That is some of the argument.

Well, aside from that question, it included also, did it not, extended life of the four reactors at Savannah River?

Mr. Meinhardt. Yes, sir; it included that surveillance program.

Senator McClure. And that was on all four reactors?

Mr. Meinhardt. Yes, sir.

Senator McClure. At that time.

Mr. MEINHARDT. Yes, sir.

Senator McCLURE. And since then we have discovered a problem with one of the four?

Mr. MEINHARDT. Yes, sir; C reactor.

Senator McCLURE. And you have reduced operating levels of the other three, although you said that 3 to 6 months from now you hope to have all of that solved, at least for a time.

And I don't mean to beat a dead horse, I am just trying to figure out where we are going because, as Secretary Herrington has said, now that we are going to work a new production reactor in, we are going to start that process over again. And yet we have got time lines. N Reactor is going to phase out. The Savannah River reactors are old and they are subject to unforeseen occurrences. And not safety. And I want to make certain that when I say that we are not damaging the public safety, but at least we are taking some risk with respect to our production capacity. And we have got all of our eggs right now in the twin baskets of Savannah River and the N Reactor. The SIS is coming on, but it won't come on now until 1995 or in that regime.

Mr. MEINHARDT. Yes, sir.

Senator McCLURE. And if it started today, when would a new production reactor come on?

Mr. MEINHARDT. That is at least a 10- to 12-year program.

Senator McCLURE. So you have got a gap after the N Reactor shuts down.

Mr. MEINHARDT. Yes, sir; we do. No question.

Senator McCLURE. Well, we have a severely time-constrained production capacity.

Mr. MEINHARDT. Yes, sir. We have a time constraint, and a technical constraint, and we have a very good reason to be nervous.

Senator McCLURE. Well, I don't mean to belabor the question of the reasons why the NPR was dropped, but many of the subsequent events would indicate that we would have been better to go ahead; isn't that correct?

Mr. MEINHARDT. Yes, sir; no question.

Senator McCLURE. And you cannot regain the time.

Mr. MEINHARDT. No; we cannot.

ADDITIONAL PREPARED QUESTIONS SUBMITTED BY SENATOR MCCLURE

Senator McCLURE. I do have a number of other questions, Mr. Chairman, which I would like to submit for the record.

[The questions and answers follow:]

QUESTIONS SUBMITTED BY SENATOR McCLURE

New Production Reactor

Question: In the late 1970's and early 1980's, the need for a replacement production reactor for nuclear material production was validated in studies conducted by three separate panels. The most recent of these, the Glennan Commission, recommended that a New Production Reactor (NPR) be constructed to assure an adequate supply of strategic nuclear materials in the 1990's. Subsequently, in 1983, then Secretary of Energy, Don Paul Hodel announced the Idaho National Engineering Laboratory as the preferred site for an NPR, with an Environmental Impact Statement to be completed in 18 months. Presumably, construction would then begin. However, in the spring of 1987, an EIS has not been completed, nor has construction begun. Why was this project stopped?

Answer: The work on the Environmental Impact Statement, EIS, was never begun because the Committee on Armed Services of the House of Representatives informed the Department of Energy by letter on September 13, 1983, that the Department should not initiate the preparation of an EIS relative to a New Production Reactor, NPR. However, although a project, 82-D-200, for construction of an NPR was authorized by Congress, no funds were appropriated for the project by Congress.

Nuclear Materials Production Strategy

Question: Has the Department established an overall strategy for assuring a viable nuclear materials production capability, or is one presently being developed?

Answer: The Department of Energy continuously revises and evaluates its strategy for assuring a viable nuclear materials production capability. At this time, a strategy involving a New Production Reactor and the Special Isotope Separation programs make up a major effort to ensure the continuing availability of nuclear materials for the nation's defense.

Dual Production Capability

Question: The N Reactor at Hanford, and the Heavy Water Reactors at Savannah River established the concept of duality of sites. Does DOE plan to continue dual production capability?

Answer: Providing redundancy for critical elements of the production complex including the use of dual production capability where appropriate, is an important consideration and the Department of Energy does not now plan to discontinue this consideration in its current operations and future planning. However, the need for, and ability to implement this concept is a function of many factors which vary over time, including the age and reliability of facilities, the required versus available capacity, funding constraints, etc. Therefore, the extent of future implementation of this concept is being considered as part of the Department's ongoing strategic planning activity.

SIS and Production Reactors Target Schedule

Question: Has DOE established a target schedule (and order) for the replacement or addition of new production systems--including the production reactors and the SIS?

Answer: The Department's schedule for the Special Isotope Separation, SIS, calls for start-up of the facility in FY 1995 with full production being accomplished in FY 1996. This schedule assumes the successful accomplishment of development tasks in time to support the beginning of major physical construction in FY 1990 and the continued availability of required funding levels through FY 1995. After the Department decides to request funding for a New Production Reactor, a detailed target schedule will be developed during the process of defining a reference concept and site for preparation of an SIS.

Contingency Plans

Question: Are contingency plans in place in the event one of the current production facilities--such as the N Reactor--is lost?

Answer: Contingency plans to minimize the impact of the loss of a major Department of Energy production facility, such as the N Reactor, have been considered in the overall long-term planning for the production of nuclear materials. However, in many cases, providing sufficient capability to fully mitigate the impact has not been possible within existing budget constraints.

New Production Reactor

Question: Will a New Production Reactor (NPR) be required to meet all current safety and environmental regulations and standards?

Answer: A New Production Reactor will be required to meet all applicable current safety and environmental regulations and standards.

Question: Will DOE consider reactor systems in which all of the byproduct heat is dumped into the environment?

Answer: Among the alternatives under consideration for a New Production Reactor are reactor systems which produce byproduct heat at a level which is not practical for use in generating power, and thus must be dumped into the environment. This would be accomplished according to environmentally sound practices and within current environmental regulations and standards just as in the case of the substantial quantity of residual heat which must be disposed of from reactor concepts which provide for power generation.

Question: Does DOE consider there are any overall national benefits that could be derived from the selection of an advanced reactor for an NPR provided, of course, it can meet the production requirements?

Answer: The Department is evaluating several advanced reactor concepts among all the alternatives under consideration for the New Production Reactor, NPR. If such advanced reactor concepts can provide a high level of assurance of meeting the necessary production requirements on the required schedule and at a reasonable level of cost, the benefit of developing such advanced concepts will certainly play a part in the decision on the final selection of the NPR concept. To assist the Department in this endeavor, the National Research Council has been requested to evaluate two advanced reactor concepts, the High Temperature Gas Reactor and the Liquid Metal Fast Breeder Reactor, as potential candidates for an NPR.

Independent Monitoring of DOE Facilities

Question: Does the Department accept the very real possibility of having an external, independent agency monitor the safety and environmental conditions of DOE facilities?

Answer: The Department of Energy, DOE, recognizes the possibility of having an external, independent agency monitor the safety and environmental condition of it's facilities. Although the Department has maintained in the past that these activities can best be accomplished in the existing internal DOE programs relative to safety and environmental activities, which utilize outside independent experts extensively on a routine basis, DOE is open to reconsidering this position and is looking forward to the results of the current National Academy of Sciences review of DOE reactors which will address this issue.

Heavy Water Reactor

Question: Does DOE believe that it can design and build a Low Temperature Heavy Water Reactor (HWR) of the Savannah River type on a schedule substantially different from other candidate systems, assuming all have to meet current safety and environmental standards?

Answer: Current estimates of overall project schedule for a modern version of a Heavy Water Reactor indicate that a total time from project authorization to operation would be approximately 8 to 10 years, including preparation of the required National Environmental Policy Act documentation. Schedules for other concepts indicate timeframes of 9 to 12 years.

Question: When was the last HWR reactor designed and built in the U.S.?

Answer: The last large scale Heavy Water Reactor constructed was the C Reactor at the Savannah River Plant. It was completed in 1954. The Department has been upgrading these reactors on a continuing basis since they were built. For example, the Savannah River Plant was in the forefront of integrating computers into the safety and control systems of the reactors to enhance the safe operation of these facilities.

Question: Is there any current design and licensing experience with heavy water reactors in the U.S.?

Answer: There is no current Nuclear Regulatory Commission licensing experience with Heavy Water Reactors, HWR, in the U.S. Since the majority of licensing experience in the U.S. deals with Light Water Reactors, much of the same technology utilized in the current U.S. commercial power reactor licensing process would be applicable to an HWR. Relative to HWR design experience, the continuing HWR upgrading activities have provided a stong HWR design capacity which could be made available to an HWR New Production Reactor effort.

Question: Do up-to-date licensing standards and criteria exist for heavy water or pressure tube reactors in the U.S.?

Answer: Current licensing standards and criteria are available for light water type commercial power reactors. Many of these can be applied to many components of either a Heavy Water Reactor or a pressure tube reactor.

Question: It seems that the primary purpose for building a heavy water reactor as a production reactor is based upon the premise that it would take less time to design and build than other systems, because it is a "proven" concept. Isn't it possible that building a new heavy water reactor to meet current codes and standards could delay the project to where it lost this competitive edge?

Answer: Since a Heavy Water Reactor, HWR, would utilize many components and systems already covered under current codes and standards and in view of the fact that the fuel and target technology for an HWR is well proven, it is likely that an HWR will retain a 1 to 3 year schedule advantage over other alternatives.

WPN-1 Study

Question: Has the Department initiated any actions beyond the WPN-1 study directed at the selection of a New Production Reactor?

Answer: Further actions and studies directed at the selection of a New Production Reactor design will begin after the Department decides to request funding to go forward for a New Production Reactor.

Modular Production Reactors

Question: Has the Department developed studies that address the feasibility of modular production reactors? If so, please explain.

Answer: A study conducted for the Department of Energy in FY 1985 and FY 1986 considered such alternatives as modular production reactors. The study evaluated the following reactor concepts:

Small Special Water Reactor
Small Low Temperature Heavy Water Reactor
Small Light Water Graphite Moderated Reactor
Modular High Temperature Gas Cooled Reactor

The purpose of this study was to explore the feasibility, cost, schedules, etc., of smaller reactor concepts which could offer potential siting/cost/schedule opportunities.

NPR Projected Cost

Question: What is the projected cost of an NPR?

Answer: The total capital cost, including support facilities, of construction of various New Production Reactor concepts are as follows: conversion of the WNP-1 to a production reactor would cost about $2.0 billion, exclusive of any costs to acquire the existing facility; a new Low Temperature Heavy Water Reactor about $2.2 billion, $0.2 billion of which is allocated for heavy water existing at Savannah River; and a Modular High Temperature Gas Reactor about $3.5 billion. These estimates are in FY 1986 dollars and are, of course, preconceptual.

Question: The funding requirements of new production systems will further stress the Department's budget and constrain DOE's ability to adequately support other programs which have the potential to contribute to the national energy supply as well as national energy security. Given this constraint, isn't it essential that considerations of a New Production Reactor include not only the material production objectives, but ways the program can support other DOE and national interests?

Answer: The Department of Energy will give consideration to all aspects of each alternative technology for a New Production Reactor; both positive and negative. In the final analysis, the decision will be based on which technology will best serve all the needs and objectives of the Department and national interests.

Sale of Byproduct Steam

Question: Given the continuous need for tritium, and the high costs associated with the construction of a reactor to produce it, shouldn't DOE be sensitive to life cycle costs and attempt to offset the ongoing costs with the sale of byproduct steam?

Answer: The Department of Energy is sensitive to life cycle costs, including the utilization of the existing Defense Programs infrastructure and ultimate disposition of nuclear waste in addition to the sale of byproduct steam from a New Production Reactor, as one factor in it's decisionmaking process.

Question: Wouldn't a co-producing system have the additional advantage of a reactor facility that could continue producing power and not have to be mothballed or decommissioned if we are successful in achieving arms reduction?

Answer: The primary purpose of a New Production Reactor is to provide a reliable source of tritium, which, because of its short half life, 12½ years, will continue to be required even if arms reduction efforts are successful.

USSR Production Reactors

Question: Isn't it true that the production reactors in the USSR are all capable of producing power?

Answer: DELETED

N Reactor and Savannah River Reactors Funding

Question: What is the FY 1988 funding request for the operation of N Reactor at full power? For full power operation of the Savannah River reactors?

Answer: The FY 1988 funding request for the operation of N Reactor and Savannah River reactors at full power is approximately $210.1 million and $279.9 million, respectively. These funding levels do not include supporting services and capital costs associated with the operations of N Reactor and the Savannah River reactors.

New Production Reactor

Question: It is clear that the current problems with the nation's material production systems will soon force the Department of Energy and the Department of Defense to begin building a New Production Reactor. Isn't it a fact that the schedule for designing and building such a reactor will be the same for any new NPR, when necessary environmental and safety concerns are addressed in the design?

Answer: Current schedule estimates indicate that a Heavy Water Reactor would require 8 to 10 years to design, build, and begin operation; other technologies would take from 9 to 12 years. Both these estimates include appropriate time for environmental and safety issues to be addressed.

Question: The Liquid Metal Reactor is being assessed as a NPR possibility, along with the High Temperature Gas Reactor. Can an LMR make tritium? Has the R&D for targets in an LMR been developed?

Answer: A Liquid Metal Reactor, LMR, is technically capable of producing tritium. However, because of LMR characteristics, it is not as efficient as other New Production Reactor concepts at producing tritium. The necessary technology for targets for such an LMR has not been developed.

HWR Sole Source Contract

Question: Given today's Federal procurement requirements, will it be possible for DOE to award a sole source contract for the Low Temperature Heavy Water Reactor?

Answer: Sole source procurements are possible under current procurement regulations. This issue has not yet been considered relative to procurement of a Heavy Water Reactor. The selection of a site and a technology must be made prior to determining the need and potential for such a sole source contractor.

NEW REACTOR TECHNOLOGIES

Senator JOHNSTON. Before I call on Senator Sasser, can you tell me what technologies would compete with the new reactor?

Mr. MEINHARDT. I am sure that they would all compete to some degree, but it is a matter of what is available. We certainly have the technology of the Savannah River reactors, which are heavy water moderator reactors. You have a pressurized water reactor, such as you have in the common commercial reactor today. You would have the HTGR, or high temperature gas-cooled reactor. There is some question about the LMFBR as a tritium producer.

Again, let me reiterate. The reason you would go after a new production reactor is to assure yourself a supply of tritium. As we pointed out earlier, that is the crucial product and that is the one you would go for first. But those are four technologies that I think are the leading technologies.

Senator JOHNSTON. HTGR is in the running?

Mr. MEINHARDT. Certainly.

Mr. FOLEY. Let me comment on that just a little bit too, sir. Under Secretary Salgado has asked the National Academy of Sciences and the National Academy of Engineering to take a look at the high temperature gas-cooled reactor and a look at liquid metal reactor technology and give a report back to him as quickly as they can. And we already have proven technology in the types that are down at Savannah River. So I would say that all of those are in the finals that we are with now.

Senator JOHNSTON. Thank you.

Senator Sasser?

SAVANNAH RIVER REACTORS

Senator MCCLURE. Could I make one comment? And I thought maybe you might too, Mr. Chairman. As the chairman of the Energy and Natural Resources Committee, we did have a hearing on it up there just a couple of days after the operating constraints for the Savannah reactors were known to the Department. And in spite of the fact they were known to the Department, the witnesses from the Department did not breathe one word of it at the hearing.

And I would hope that we can expect a little more forthcoming communications from the Department than we got at that particular time.

Mr. FOLEY. Let me comment on that.

Senator MCCLURE. Surely.

Mr. FOLEY. I was not there, so it is easy for me to make a comment because I wasn't there.

Senator MCCLURE. Well, I realize you weren't there. And the people who were there are not here today. But I thought maybe if I said it here today they might hear downtown.

Mr. FOLEY. Oh, I think they probably will. And I thought perhaps if I made a statement you all might hear it right here, too, sir.

Senator MCCLURE. Yes, sir.

Mr. FOLEY. And that is that Mary Walker, the Assistant Secretary for Environment, Safety and Health, was the principal witness. I know that she had come back from a trip 1½ days before, just something like that, just before the hearing. And I was a party to putting testimony together at about 7 o'clock the night before. And, quite candidly, I think we were naive as a Department in coming on in and not bringing the subject up because while it was in the written testimony, we didn't think it would get the reaction that it got, quite frankly. And so with all due apologies and no intent on anybody's part to be sneaky or deceptive or anything like that, we blew it, and it was just, frankly, naive and overdone on my part.

Senator MCCLURE. Well, I only expressed enough to beat a dead horse in the hopes that you will not be that naive the next time.

Mr. FOLEY. If we could think of anything else that we could pass on to you as a heads up today, sir, we will do it. [Laughter.]

Senator MCCLURE. Which is a way of saying there ain't nothing else to tell. OK. But I was concerned about it, and I know the whole committee was concerned about it. Because it, in effect, blindsided a number of the members of the committee who might otherwise have been prepared to ask some questions, or at least been receptive to some assurances that the Department missed the opportunity to get that step ahead of the current events.

Mr. FOLEY. Yes, sir.

Senator McClure. Thank you, Mr. Chairman.

Mr. Meinhardt. I would just like to add, sir, you are very kind in using the words you do, or the tone that you are using. I have got a much stronger word and different tones from at least one member of the South Carolina delegation. [Laughter.]

Senator Sasser. And I know who that was.

Mr. Foley. Having been over first from Ohio, I got the same sort of commentary. [Laughter.]

Senator Johnston. Senator Sasser.

PLUTONIUM REQUIREMENTS

Senator Sasser. Gentlemen, we are talking here apparently about [deleted].

Mr. Meinhardt. If we are able to operate N Reactor at Richland, Wash., and able to operate our reactors at Savannah River, according to the current program, [deleted].

Now what is critical there is the operation of N Reactor. If you subtract out N Reactor's contribution from the curve that you are viewing, [deleted].

Senator Sasser. [Deleted.]

Mr. Meinhardt. [Deleted.]

Senator Sasser. Well I guess more specifically my question would be, can we continue to meet the need for weapons-grade plutonium with the present level of systems that we have on line and provide the weapons grade plutonium that we might need for a Midgetman system, for example, [deleted] without the N Reactor?

Mr. Foley. We would have to adjust something so all of them fit.

General Falter. That is, of course, the concern that the Defense Department has. The requirements for the weapon systems are fairly well established. And, of course, the small ICBM would be one eventual claimant if it was given the go-ahead. Our concern is the ability to produce those things that are necessary to maintain the deterrent.

Historically, I think, though, we have to recognize that two things have occurred. First, the question came up earlier when you were gone, sir, that asked whether the requirements have habitually been overstated. And the answer is, I think that they have been overstated to a certain extent, in that the Defense Department has been very optimistic. It has been an easy matter for us to just turn around and tell the Department of Energy what to build and they can do it. You know, these are requirements, and these are the years and we are never going to slip the system. So I think that there has been a great deal of optimism that has been built in.

The second thing I think is that the production has pretty well been overstated, because you are dealing with a physical phenomenon: how long it takes to convert a plutonium target into actual plutonium, and how many hours and how many workdays there are to a reactor cycle. And our experience has been here recently, at least, in watching the DOE complex, that C reactor went down, which was a totally unpredictable event. So their production was overstated in that regard.

The N Reactor has run into periodic difficulties. It looks like a perfectly safe reactor that fixes can be put to and it could get back into production. But, again, that is an unpredictable event. We don't know precisely when that is going to happen.

So I think you have got two things that we are talking about in response to your question. The requirements have been historically overstated, and we purged them last year. The Department of Defense did this with the Department of Energy's help, and the joint document in the stockpile memorandum is a pretty clean document right now in terms of requirements.

And as for the production, I think there is an excellent grip on the part of the Department of Energy and an excellent understanding on the part of the Department of Defense on what the production requirements are capabilities are. But there are still unpredictable elements, too.

If the Congress were to decide, for example, that the small ICBM is not going to be built, or we are not going to build *x* number of submarines, and, consequently, *y* number of missiles to arm them, the requirements could change. If, in fact, another reactor were to go down permanently, the production would change.

So what I am saying is that the data I think that you have seen here today is something that the Department of Defense feels very uncomfortable as far as the production capability. We are comfortable that we know what we are talking about in requirements, but we don't want to give the impression that neither of those can change.

Mr. FOLEY. I will tell you why I am very uncomfortable and that is that in the 1½ years and a half or so that I have been working on this, it is the fragility of the complex that makes me very uncomfortable. When I came in 1½ years ago, and where we are right now, is a different story entirely. With C reactor down, with N Reactor down for 6 months, with the Savannah River reactors throttled back to 50 percent, and over the past years the production complex output has been tailing down a little bit each year with the best efforts and monies going on into trying to buttress it up. You pay a price, per se. And we can hack it, we can put the material out the front door, the number of weapons that you are asking for, without taking some of the complex down and replacing it. So you are bow waving all of this general maintenance and replacement and orderly buttressing up of the system. And you are beginning to pay the price for that now. So that my assurance or guarantee that we are going to be able to meet these production needs is diminishing almost day by day. And that is the real world, whether or not we can put the stuff out the door that Defense is going to need.

Senator SASSER. Gentlemen, thank you.

Mr. Chairman, thank you.

SUBCOMMITTEE RECESS

Senator JOHNSTON. Thank you very much, Admiral, General, and Mr. Meinhardt. You have provided excellent testimony today. We will stand in recess subject to call. Thank you.

[Whereupon, at 4:10 p.m. Monday, April 6, the subcommittee was recessed to reconvene at 2 p.m. Wednesday, April 22.]

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

WEDNESDAY, APRIL 22, 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:13 p.m. in room SD–116, Dirksen Senate Office Building, Hon. J. Bennett Johnston (chairman) presiding.

Present: Senators Johnston, Sasser, McClure, Cochran, and Domenici.

DEPARTMENT OF ENERGY

NAVAL NUCLEAR REACTOR PROPULSION PROGRAM

STATEMENT OF ADM. KINNAIRD R. McKEE, U.S. NAVY, DIRECTOR, NAVAL NUCLEAR PROPULSION

Senator JOHNSTON. The hearing will come to order.

We welcome to the committee Adm. Kinnaird R. McKee, Director of the Naval Nuclear Propulsion Program, to present testimony in support of the fiscal year 1988 budget request for a total of $612 million.

Admiral, I am very pleased to have you here, especially after having been on your submarine.

Admiral McKEE. Thank you, sir.

PREPARED STATEMENT

Senator JOHNSTON. I am very impressed with the nuclear Navy and with the job you are doing.

Of course, your written statement will be made part of the record; so, please proceed as you wish.

Admiral McKEE. All right, sir.

[The statement follows:]

STATEMENT OF ADM. KINNAIRD R. MCKEE, U.S. NAVY

This is a landmark year for naval nuclear propulsion. Forty years ago, the Naval Nuclear Propulsion Program began work on the first prototype naval reactor plant. Today we have 178 reactors operating worldwide. This year, work continues in all areas of naval nuclear propulsion. Our principal research and development effort will be the propulsion plant for the Navy's new attack submarine, SSN-21. Last year, Congress made a significant investment in the future by authorizing long lead material for SEAWOLF, first ship of the new class. The Navy is requesting you to authorize construction in FY 1989. I will discuss this work in more detail, but first I would like to bring you up to date on the overall program.

Naval Reactors' responsibilities continue to grow. Last year 5 nuclear powered ships joined the fleet, bringing the total to 149, in addition to 8 land-based prototype plants. In the past year, nuclear powered ships conducted missions of major national importance and made several other crucial deployments. Submarines demonstrated versatility and flexibility in unique under-ice operations culminating in a rendezvous of three ships at the North Pole. This overall exercise was the biggest Arctic operation in history. In short, nuclear powered ships have demonstrated remarkable operational capabilities on all fronts, while maintaining their unparalleled safety and environmental compliance records. Accompanying our responsibility to support these operations are increasing requirements to train naval reactor plant operators, continuing development of advanced reactor plant concepts, and an ever-increasing population of operating plants.

Safety remains one of our highest priorities. Two catastrophic events last year shattered any tendency toward complacency about the infallibility of technology. Chernobyl emphasized the overriding need to ensure safe reactor plant operation. But to me, Challenger was more significant because it reinforced the continuing need for exceptional attention to all details of our technical work.

For perspective, consider that the Naval Nuclear Propulsion Program has almost twice as many operating reactors as all the civilian nuclear power generation plants in the United States. Nuclear powered ships have now steamed over 65 million miles -- 3,100 years of reactor operation -- without a reactor accident or any radioactivity release having a significant environmental effect. The attached publications provide relevant statistics for last year. Although we are proud of this fine safety record, it also represents a potential vulnerability in that it could encourage complacency. We must never forget that safety, which is critically important in its own right, is also the basis for the public confidence that has allowed our nuclear powered ships to operate around the world, at sea and in port.

The Soviets also recognize the importance of Naval nuclear power, in surface ships as well as submarines. They have a major commitment to submarine development because they recognize that as the route to maritime supremacy.

Some public perceptions to the contrary, the Soviets use basically the same approach to submarine development as we do, but they apply a far greater industrial effort. They started a long way behind, but have been making consistent, impressive progress. The Soviets understand that one quiet, well-armed, balanced submarine is a match for many less capable ships. Their latest design, AKULA, uses this balanced approach. It represents a Soviet answer to the Navy's highly capable and versatile 688

Class attack submarines. With upgrades we are now making, the 688 Class will still provide us an adequate margin of superiority over AKULA and its predecessors, but we must look to the future. That is the purpose of SSN-21 -- to ensure our margin against future Soviet developments into the next century.

SSN-21 will significantly advance submarine warfare technology. Never have so many discrete technology developments been consolidated in a single submarine. SSN-21 will be quieter and more heavily armed than any attack submarine in history. The propulsion plant incorporates many developing technologies. We will get more power per pound from the Advanced Fleet Reactor plant than any submarine reactor plant to date. Improved fuels and materials will help us draw every possible ounce of performance from the plant. Enhanced quieting techniques will considerably reduce noise over SSN-21's entire speed range. Though no single feature could be considered revolutionary, the aggregate merits that description. For the first time a submarine will take full advantage not only of the endurance but also the mobility afforded by nuclear power, without sacrificing firepower or combat effectiveness.

SSN-21 will be a remarkable ship, but critical to the successful application of this technology, as always, are people. Our nuclear-trained officers and men are the best -- highly trained, honed to a fine edge, refining and maintaining the technical skills demanded by this complex technology. They work hard, meeting unparalleled standards of professional competence. In return, we reward them with long hours and the promise of extended deployments far away from home and family. There is intrinsic satisfaction from the job, but we owe them more than just a pat on the back. Congress has acknowledged this, and has provided measures of recognition. We must keep in mind that these people are our most valuable resource, and continue to treat them accordingly.

In deliberating the budget, Congress must weigh the merits of competing options. In such an environment, the best investments are in systems which offer the greatest strategic and tactical leverage. Nuclear powered ships have to be at the top of that list. They make up nearly half the Navy's combatants and comprise the entire sea-going strategic deterrent force, yet require relatively small resources. Their superlative crews further enrich the return from our investment.

Your past support is responsible for the success enjoyed by these ships and these men; your continued support will ensure we retain the edge we now enjoy.

Naval Reactors Development Budget Request

The budget request for Fiscal Years 1988 and 1989 provides the funding necessary to support SSN-21 development, help protect the investment we have in existing nuclear powered ships and prototype plants, and continue developing improved naval nuclear propulsion plant technology. Fabricating, testing and analyzing Advanced Fleet Reactor components and fuel systems for SSN-21 will continue in Fiscal Years 1988 and 1989. A mechanical core mockup and all reactor equipment will be installed in a laboratory test facility for integrated testing; this will support preparation for installing the initial core in a prototype reactor plant.

We are in the middle of a heavy servicing period for the eight land-based prototype nuclear reactor plants. These plants are essential for testing and for training Navy reactor plant operators. Servicing will ensure continued prototype plant operation within acceptable safety and reliability margins.

The Fiscal Year 1988 budget request totals $612.0 million, a six percent increase over Fiscal Year 1987. Roughly half of the increase is due to escalation. The remainder comes from prototype plant servicing requirements and the initiation of three small construction projects.

For Fiscal Year 1989, the request is $647.6 million. Again, this represents a six percent increase over the prior year's requirements with roughly half the increase due to escalation. The remainder is primarily due to continued growth in prototype plant servicing requirements which peak in Fiscal Year 1989.

A discussion of the budget requests by major area follows:

	Budget Authority (in millions)	
	FY 1988	FY 1989
Operating Expenses:		
Reactor Development	$249.7	$241.0
Plant Development	74.0	80.0
Reactor Operation & Evaluation	208.0	234.0
Program Direction	12.4	13.0
Subtotal Operating Expenses	$544.1	$568.0
Capital Equipment	50.0	53.0
Construction	17.9	26.6
TOTAL NAVAL REACTORS DEVELOPMENT	$612.0	$647.6

Reactor Development

Reactor Development focuses on improving the power capability, reliability and endurance of naval reactors. Developing new reactors and improving existing equipment is crucial to achieving the propulsion plant performance necessary to support the expanding role of the Navy's nuclear powered fleet.

The Advanced Fleet Reactor will power the next generation of nuclear powered attack submarines and is the Program's primary development effort. This work will include: fabricating prototype reactor components and core instrumentation; installing reactor components in a laboratory test facility for integrated reactor plant assembly, flow, noise and arrangement testing; analysis and testing of the fuel system design; and thermal/hydraulic and mechanical tests and analysis of the reactor design.

Achieving enhanced performance in naval reactors requires integrating the experience gained from operating reactors with advanced concepts resulting from applied research and emergent technology. Data obtained and evaluated from operating fleet and prototype reactors as well as analyses of expended naval reactor cores provides feedback on the performance of reactor designs and indicates the areas where future development efforts should concentrate. This data is also crucial to ensuring continued safe reactor operation.

An extensive technology effort is conducted to develop new and improved fuels, poisons, and materials as well as to improve manufacturing techniques. Improved fuels, poisons, and materials are critical to achieving higher power, longer life cores. Better manufacturing techniques enable these improvements to be combined, producing a reactor design with enhanced performance, increased reliability, and better serviceability. Toward these goals, work in FY 1988 and FY 1989 will include: expanding computing capabilities and developing sophisticated computer codes to predict and evaluate reactor plant performance; completing the Developmental Materials Core which will be used to test new fuels and materials; developing advanced heat treatment methods to improve corrosion resistance of reactor materials; continuing Modified Fuel Process refinement; evaluating reactor concepts, developing improved manufacturing processes and inspection techniques; and designing, testing and evaluating advanced fuel systems, cores and components for future applications.

Plant Development

Enhancing naval nuclear propulsion plant performance requires not only better reactor designs but concurrently improved performance of all reactor plant components and systems. Plant Development strives to integrate and improve reactor plant performance as a whole. This effort supports both operating plants and research into advanced concepts and equipment. Integral to Plant Development work is ensuring continued plant safety and reliability. This includes establishing quality assurance standards and developing better methods to reduce the level of radioactivity in operating plants by such processes as decontamination.

Plant arrangement studies aim at improving efficiency and maximizing performance of reactor plant components and systems. New instrumentation and control equipment concepts are evaluated to enhance systems operations. Materials and chemistry technology work is performed to develop improved water chemistries and analyze corrosion, fatigue and structural characteristics of new and existing materials concepts. These integrated efforts produce the technology for improving existing reactor plant components and systems and designing advanced plant concepts.

Work in support of these activities includes: testing and evaluating component and system performance; developing and fabricating prototype instrumentation and control equipment for advanced plant applications; developing heat and fluid transfer test components; testing, evaluating and determining how to apply new material to new components; performing fluid flow and plant arrangement studies; studying new coolant chemistry effects on corrosion and material fatigue; and continuing radiation monitoring, quality assurance activities, and environmental upgrading to ensure safe working environments and to allow extended use of existing facilities.

Reactor Operation and Evaluation

Eight land-based prototype naval nuclear propulsion plants are operated, maintained, and serviced to test developmental cores, components, materials, and systems and to train Navy personnel as reactor plant operators. Prototype testing in an actual operating environment is essential to confirm new designs developed in the laboratories and to discover and resolve any potential problems which would otherwise interfere with fleet activities.

An intense period of servicing the prototype plants began in 1984 and will continue into the early 1990's, peaking with the initial refueling of the S8G prototype plant. These servicing efforts include major prototype plant overhauls, refuelings, component examinations, and component removal and replacements, and are the major cause for growth in operating expenses. Additionally, with the average age of the prototypes approaching 25 years, we need to increase the frequency of periodic shutdowns and minor modifications if these plants are to continue operating safely and reliably.

Capital Equipment

The bulk of capital equipment funding is for replacing and enhancing laboratory computer systems, including the 18-year-old CDC 7600 computers at the Bettis laboratory, and to perform prototype plant component upgrades as part of the servicing effort to ensure safe plant operation. The remaining funds are to support test and development programs and to replace aging equipment.

Construction

Construction funding requirements in FY 1988 increase due to final funding of the Kesselring Site Facilities Upgrades project started in 1987 and to the initiation of three smaller projects. The new projects in FY 1988 will provide security improvements, construct prototype servicing facilities, and enable us to handle more efficiently the increasing number of expended fuel shipments from the fleet.

FY 1989 construction funds will complete two and continue one of the planned FY 1988 projects, and will begin three new small projects. The new FY 1989 projects will provide a facility to test new steam generator designs, enhance prototype plant safety, and upgrade safety systems at the Advanced Test Reactor in Idaho which, although not under program cognizance, provides support for all of our fuel material irradiation tests.

Program Direction

Program Direction funds pay for salaries, benefits, travel, and other expenses for 215 full time Department of Energy personnel located at headquarters and the field offices in Pittsburgh and Schenectady.

As the demands placed on the Naval Nuclear Propulsion Program increase, these highly skilled and dedicated people have assumed greater responsibilities. They are essential to the success of the Program.

PROGRAM OVERVIEW

Admiral McKEE. What I will do is give you a brief overview of the program and talk a little about the principal things we are working on. Just as a point of reference, you will recall the summary of my charter.

I will spend most of my time today talking about research and development and, to some degree, procurement. I will also talk a little bit about safety.

To put the program in perspective, my responsibility right now is for 157 operating ships and prototypes, encompassing a total of 178 reactors. We still have the largest reactor program in the free world.

The work we intend to do with the money we are discussing today starts with operating support, the business of supporting operating reactor plants in the fleet. This is our first priority.

As interested as we are in SSN-21, our first priority is the operating fleet; and the DOE, as you know, does major work in that regard.

Performance improvement—which is research and development—includes a continuing program in material development. We also are continuing to upgrade our prototypes, which in the last few years have required much more significant upgrading than they have in the past.

We also are bringing the fuel factory on line. You will recall that we began building the fuel factory about 4 years ago so that we would have a second source of nuclear fuel.

Right now, our only source is in Tennessee, a small commercial plant. They do good work, but the business aspects of their work is a matter of some concern to us.

They were owned by Getty, then Texaco, and now we are not sure who the next owner is going to be.

So, we built a government factory, and that should come on line down in Savannah River some time this year.

What I will spend most of my time talking about today, Mr. Chairman, is our reactor prototype servicing and the advanced fleet reactor, which is the work we are doing for SSN-21.

REACTOR PROTOTYPE OPERATIONS

As you know, I have eight prototypes. Some are as old as 30 years. You have heard folks in recent times complaining about the age of some reactors that are up to 20 years old.

The S1W reactor and all of its components are almost 35 years old, and it will retire in the next couple of years.

All of my prototypes, with the exception of the Trident reactor, are old machines. We continue to use them for research and development, and we continue to use them for training.

And as I told you last year, they have been operating for a long time; and as luck would have it, they have all come to the point where they will require refueling and major maintenance in about a 10-year period, from the early 1980's to the early 1990's.

This is a major expense, and a tremendous amount of energy has been devoted to the work.

Without going into detail, this shows you the number of reactors and the timing of maintenance work. The spots indicate major maintenance. We are doing a tremendous amount of major maintenance. We are going to have to overhaul and refuel almost all of them over this 10-year period of time.

The S1W reactor will go out of commission during fiscal year 1989 and will be replaced by a training ship. The training ship is an old Polaris submarine that is being converted to serve as a training facility.

The rest of these are major maintenance and refuelings, and a good bit of our budget goes toward that end.

SSN-21 REACTOR DEVELOPMENT

The other major project we have, of course, is SSN-21. Our DOE responsibility is to develop the reactor. My combined Navy and DOE responsibility is to develop the entire propulsion plant for the submarine; that work is well along.

I brought a couple of training aids along, which I won't dwell on, to give you an updated look. That is what the new submarine is going to look like.

Senator JOHNSTON. That is the attack submarine?

Admiral McKEE. Yes, sir; this is the Seawolf attack submarine. It is a very powerful machine; and in performance, it is revolutionary.

There is no one specific feature that is revolutionary, but overall the entire submarine is. This submarine, if it satisfies the goals we have set for ourselves, will give us for the first time, anywhere in the world, the ability to take advantage of the full mobility—mobility offered by nuclear power.

We have always had endurance, but we never have been able to achieve full mobility because of [deleted]. You remember what I showed you on the submarine.

[Deleted.]

Senator JOHNSTON. And that is what this can do?

Admiral McKEE. That is what it does. [Deleted.]

Senator JOHNSTON. Does this mask any of those bubbles?

Admiral McKEE. No; I will talk to you a little about that.

In general, these are the improvements that are in the submarine: [Deleted.]

If I can't achieve my goals for the propulsion plant in terms of performance and quieting, then everything else we want to do goes to pot, because they all depend upon a quiet, capable, agile, fast platform.

I will talk for a couple of minutes about acoustic advantage, because I think that is an important thing to understand.

ACOUSTIC PERFORMANCE TRENDS

If you have read the papers recently, you know that the Soviets are working very hard to overcome the disadvantage they have in submarines. And they put to sea—remember, I talked to you about it when we were at sea—a new submarine called Akula. [Deleted.] It is a very competent submarine.

There are those who would argue that it is better than anything we have. I will show you that is wrong. I think it is important for you to understand the Soviet trend and our trend, because it puts in perspective what I have to do for the SSN-21 submarine.

To talk about quieting specifics then, this displays radiated noise in decibels; and as you know, that is a log 10 function.

Senator DOMENICI. You knew that?

Senator JOHNSTON. Yes.

Senator DOMENICI. Thank you.

Admiral MCKEE. This shows how quiet a submarine is. This submarine is noisier than that one; and as you can see, as time has gone on, the various classes of Soviet submarines have gotten quieter and quieter. These are projections.

As we have built various types of submarines, they have gotten progressively quieter as well. So, we have been able to maintain this acoustic advantage all the way along and it has been a substantial advantage.

[Deleted.]

ADVANCED FLEET REACTOR

Admiral MCKEE. Unless we can build a propulsion plant—this advanced fleet reactor—that will give us that kind of acoustic performance [deleted] the combat system is not much use. The combat system also has to be on a quiet, agile platform. No matter how competent the combat system may be in itself, if it is not on the right platform, it won't work.

And if the platform doesn't work, then the rest of it doesn't work. If we don't get the power density we in the powerplant have planned for, we won't be able to carry the weapons in the submarine.

So, the powerplant development is critical.

These are the improvements that we have set for ourselves. As I said, quieting, power density—and producibility.

Producibility, of course, because we want to be able to afford the SSN-21, and we need to do the things now in the design that will make it producible at a reasonable cost.

From the Department of Energy's standpoint, to accomplish that requires us to do these things to the reactor itself—the high-powered low-flow reactor.

[Deleted.]

SSN-21 RESEARCH AND DEVELOPMENT FUNDING

Senator JOHNSTON. All right. What were your problems?

Admiral MCKEE. The R&D Subcommittee of the House authorizing committee voted to zero research and development on the SSN-21. They did so without all parties being heard from. In the 5 years I have had this job, I have never testified before them.

They did it at the urging of one staff member and on the basis that the Akula—at least the alleged basis—was that the Akula was already better than the 688 and clearly better even than the SSN-21. They concluded that we ought to stop where we are and study what to do.

Now, studying what to do is what we do best.

We built the 637 class back in 1967; we started working on the design of the 688 when I was a lieutenant commander. We built the 688 in about 5 years, and since then we have done nothing but study, study, study. These are all studies.

All this effort will convert to what amounts to a building program in the 1990's. We have been put in the position of having done nothing but study for over 15 years; and by studying, we were to beat the Soviet threat.

Now, I fail to understand the logic in that, but that is what it is all about.

By studying, we were to go out and put extra money against specific technical areas, which would eventually—some time off in the future—lead to a new far higher performing submarine, which might be able to take this guy—the 1990's—on, and that is hard to see.

When that happened, the House Sea Power Subcommittee, which had already voted to support the submarine and has already authorized almost $400 million in long-lead material for the submarine—not for studies, but to build the equipment for the submarine—recognizing that no hearings had been held by the R&D Subcommittee, held a hearing. Vice Adm. Bruce Dellars and I testified and the staff member presented his case.

They also invited members of the R&D Subcommittee to the hearing since they had not had an opportunity to hear both sides of the issue.

Three members of the R&D Subcommittee—the chairman and two others—came and we had a pretty lively hearing. After the hearing, the full committee voted to restore the money and put in $100 million extra for additional work. That is where we stand today.

The staff member announced that his purpose in doing this was to get the Navy's attention so that they would work on these important technologies. It was a hostage-taking exercise. [Laughter.]

We hope that the subcommittee is satisfied now. There has been an awful lot in the paper about it, and we don't like to see that.

Senator JOHNSTON. We can use that $100 million for something else, can't we?

Admiral MCKEE. I am not going to tell you——

[Laughter.]

Admiral McKEE. The fact is, advanced fleet reactor hardware is being made today. I will briefly cover this, and then I will let these other folks get started.

[Deleted.] This is the reactor compartment. So, we really know what we are doing. We are no longer in a theoretical stage. [Deleted.]

Admiral McKEE. This gives you an idea of the level of detail to which we are working. We decided to model the propulsion plant in wood because it is easier to make changes in wood than it is steel. [Deleted.]

[Deleted.]

Admiral McKEE. The point in all of this is not to try to take you through the details. The point is that we are well along. We are committed, and we are building things that will actually go in a prototype and in the ship.

ECONOMICS AND PRODUCIBILITY

Another thing that is different about the new boat is that we have had longer—5 years—in the design process.

We must compartmentalize the design if we are going to be able to build it more economically than we build the 688 boats. We have to have the design on each piece virtually complete, whereas in the old days we designed the outside and started building and designing as we went along.

Senator JOHNSTON. Have you let any contracts for those pieces?

Admiral McKEE. No; they will all be done by whoever has the lead, but they will be done in various pieces.

The breakdown is more complex than simply the sections. For example, we will build the entire electrical distribution system as one piece. This is nothing new; the Germans did this during World War II, and they built the various sections all over Germany. That is why we couldn't stop the production.

They didn't do it so much for efficiency as they did it from the standpoint of being able to keep the factories on the line. So, it is nothing new, but it is new to us.

We are building 688's and Tridents sort of like this, but they weren't designed to be built that way. So, they are not optimal in this regard, and we don't get the maximum savings.

Senator JOHNSTON. All right. Where are those production facilities?

Admiral McKEE. The one for Electric Boat is up in Quonset, R.I. They barge the sections down. The one at Newport News is right there on the grounds. As you know, they have a lot of real estate down there.

Senator JOHNSTON. Yes.

SSN-21 DEVELOPMENT COSTS

Admiral McKEE. The budget to build all those things is just what you have seen before: operating expenses, capital equipment, and construction, comes to in 1988 $612 million and for 1989 to $647 million.

Senator JOHNSTON. Do you have the total development costs and funding profiles?

Admiral McKEE. For this?

Senator JOHNSTON. For SSN-21.

Admiral McKEE. The reactor portion of the SSN-21, out of this amount, is something on the order of $100 million in this fiscal year.

Senator JOHNSTON. The total development cost?

Admiral McKEE. The total development cost of the submarine?

Senator JOHNSTON. Yes.

Admiral McKEE. The total Navy development cost of the submarine to date is about $1 billion for mechanical and electrical work. We are on the downside of the R&D effort. We are very much on the downside on the rector plant R&D effort.

The Navy's total development cost of the SSN-21 class is expected to be a little over $4 billion in 1985 dollars.

Senator JOHNSTON. That is the total?

Admiral McKEE. R&D for the whole submarine—weapons—and the whole submarine.

SSN-21 PRODUCTION COSTS

Senator JOHNSTON. What will be the unit cost?

Admiral McKEE. The unit cost is to be $1 billion for production versions of the submarine. That figure is stated in 1985 dollars. We were assigned a bogey when we started all this.

The lead ship is to be delivered for $1.6 billion, and the follow ships, once we get down the learning curve, are to be $1 billion each. During the same time period, the 688-class ship is estimated to cost about $750 million; so, the SSN-21 is about 25 to 30 percent more expensive.

Senator JOHNSTON. More expensive than?

Admiral McKEE. Than the 688.

To put those budget numbers in some sort of perspective, we are about 6 percent of the DOE budget in 1988. Our total investment in hardware in the Navy and in the DOE is something on the order of $52 billion.

That is all I have, sir.

Senator JOHNSTON. Are you satisfied that an additional 30 percent per unit cost is worth it? [Deleted.]

Admiral McKEE. [Deleted.] Yes, sir; because the 688 is the ship that is going to have to take on the Soviets. We are building the SSN-21 against what the Soviets build beyond the Akula.

There are really substantial savings in the SSN-21 from the operational side. If you take 100 submarines today, we would be lucky to keep about [deleted] of them on station full time in wartime conditions, due to the number that are in maintenance and the ones going and coming.

[Deleted] to keep on station in the North Cape area, the Bering Sea, in the forward areas and up under the North Pole. Those are long distances, anywhere from 4,000 to 10,000 miles. So, they spend a lot of time coming and going.

[Deleted.]

FUTURE OF SUBMARINE WARFARE

Admiral McKee. We will build the SSN-21's in some number, and then eventually, we will follow them up with another submarine that will, in my judgment, by that time have to do different things.

The SSN-21 is built primarily to go kill other submarines and do other things as well. I think the next generation is going to be a whole new ball game, because I think submarine warfare is going to take an extraordinarily different position in the scheme of things by the time we get ready to build the next ones.

But we have to have the SSN-21 now.

Senator Johnston. What extraordinarily different schemes?

Admiral McKee. We are going to get to the point where submarines—typically at slow speeds—that have nothing to do aren't going to be able to be found by anybody.

The idea that you can go out in airplanes and find them or surface ships and find them or submarines and find them is just wrong. We will find them only in two conditions: Where they think they are safe from attack—that is, near their own home waters—and when they display the sorts of vulnerabilities you have to display when you commit to approach for the attack—high speed, rapid maneuver, weapons launch, and those kinds of things.

That means that submarines are probably going to be called on to do more and different things. They already do four of the six missions of the Navy, although their principal role is antisubmarine warfare.

I think we are going to want to—and I am an old garage mechanic and won't be around when it happens—but my view is that you will see in the future a desire—a need—to take those other missions that the submarine can do and design a submarine which will enhance those missions because they can do it better, because nothing else is going to survive.

Senator Johnston. Those missions being what?

Senator Cochran. Which four were you about to mention?

Admiral McKee. Antisubmarine warfare, strike warfare, mine warfare, and, to some degree, amphibious warfare for special forces.

Senator Johnston. You mean to carry troops?

Admiral McKee. Yes. [Deleted.]

NAVAL WARFARE MISSIONS

Senator Johnston. Admiral, I have heard it said that in naval warfare there are two kinds of ships. There are targets and there are submarines.

What is your response to that?

Admiral McKee. All of my submarine people believe that, and that is exactly what they ought to believe.

The fact is you need a balanced fleet because there are things that submarines don't do as well as surface ships. An aircraft carrier laying off the Libyan coast will make a bigger impression on Mr. Kadafi than two or three nuclear submarines laying off his coast, and that is a fact.

There are things that submarines do better than aircraft carriers, like operating alone in waters controlled by the enemy.

The young men manning our submarines are brought up to understand if they get where they have been sent and they are not outnumbered, they have been sent to the wrong place. This is where that "submarines and targets" business comes from.

SSN-21 TO SOVIET SUBMARINES

Senator COCHRAN. Admiral, how does the SSN-21 compare to the latest Soviet attack submarine?

Admiral MCKEE. This model is the latest attack Soviet submarine. [Deleted.]

SUBMARINE WARFARE STRATEGY

Senator JOHNSTON. Senator McClure?

Senator MCCLURE. You didn't mention one fact of sea warfare and that is protection of sea lanes of communication.

Admiral MCKEE. That is where antisubmarine warfare and strike warfare come in. The submarine has a clear role in that, and the most important thing that a submarine can contribute is to bottle the other guy up at home.

What we would hope to do when a war starts is send a large number of submarines as far forward as we can get them with the purpose of keeping the enemy from ever getting out into the deep ocean. That is an antisubmarine warfare mission.

Those same submarines armed with Tomahawks should be able to do the sort of harassment and interdiction fire—you folks who have been in the Army know what I am talking about—against Soviet air bases, to disrupt any attempt to conduct air strikes against the sea lanes of communication.

Those I think are the two principal activities those missions deal with.

NAVAL FORCE STRUCTURE

Senator MCCLURE. One of the things I worry about is our capacity to or the sustainability of a war-making capability over a period of time.

Admiral MCKEE. Yes, sir.

Senator MCCLURE. Because we have to have production facilities and distribution facilities. That means we have to get raw materials to factories, produce materials, and get them back to the fighting men at the fronts.

A lot of that will be on the surfaces of oceans.

Admiral MCKEE. Yes, sir.

Senator MCCLURE. And I am concerned whether we are really structuring our naval forces toward that end as much as we are against force projection.

Admiral MCKEE. I think the force structure is OK to do that. I think the force structure is sold more on force projection than anything else. But the fact of the matter is that the tools are there for the fleet commander to do the job of protecting sea lanes. To do so, he must use a force projection approach; putting submarines in the enemy's backyard and shooting at his airfield is certainly force projection.

Senator McCLURE. It certainly is.

Admiral McKEE. If you wait for them all to come out and take us on, they have such a preponderance of numbers in their submarine force—including their old, ancient diesels—that even though many of them are not very effective, it compounds the antisubmarine warfare problem.

The whole idea is to control concentration of force. You know, Stonewall Jackson did that. Control the concentration of force, and you do that with a combination of skillful offense and defense.

What I am saying in this filibuster is that you need a Navy that can do both and a fleet commander who can decide how to use his forces.

Senator McCLURE. The carrier task force is a tremendous aggregation of force at one spot, but it also doesn't disaggregate very well.

Admiral McKEE. But that one spot is the size of the entire Eastern United States. It is a pretty spreadout operation. A carrier is just an airfield. How you load the carrier is a function of the tactical requirement.

Right now, they carry lots of fighters and lots of attack aircraft. If you want them to protect the sea lanes of communication, it would not be hard to load them with fighters to hold off the air strikes and S-3's and helicopters to go for the ASW mission and leave the attack aircraft ashore.

There is tremendous flexibility in that. The real question is, What kind of aircraft you have aboard.

Senator McCLURE. And that airfield is still there?

Admiral McKEE. Yes, sir; that applies to any airfield.

GENESIS OF SSN-21

Senator JOHNSTON. Senator Domenici?

Senator DOMENICI. Just one question, Admiral, with reference to procedure in the Navy. The LA class is pretty old.

Admiral McKEE. Yes, sir.

Senator DOMENICI. You are modifying it somewhat.

Admiral McKEE. Modifying it extensively. There are 4,000 alterations going into that ship.

Senator DOMENICI. And now, we are talking about the next generation of submarines. Admiral McKee, in just a couple minutes—no big thesis or lec-ture—what is the rationale to go to this SSN-21? Is it the introduction of that new one by the Soviets? Or is there an ongoing mission for producing the best you can?

Admiral McKEE. The Chief of Naval Operations sets the requirements, and he looks at a variety of things. Fundamentally, he looks at how we are doing and how the other guy is doing.

This is one facet of the submarine's design, but it is an example. Here is the trend in noise quieting of the Soviets, and here is our trend in noise quieting. [Deleted.]

Let's say we built the 688 and said that's good enough. We don't need to build anything else. What you would find is that, at this point in time—[deleted] they are ahead of us.

And clearly, watching that trend was the emphasis for doing the improvements on the 688, to continue our own trend to improve the acoustic advantage; but the 688 has gone as far as it can go. We can't improve it any more.

[Deleted.]

Admiral McKEE. The next step then is to design a new submarine.

As an example, for SSN-21, the CNO commissioned submarine officers to do analytical work to determine what the characteristics of the next submarine needed to be to stay ahead of the threat in the next century, which is why they call it the 21.

Those characteristics have to do with depth, speed, and usable speed, agility, weapons load, the whole bit. He sets those requirements and gives them to the Naval Sea Systems Command.

The Naval Sea Systems Command then does conceptual design studies. The purpose of the conceptual design study is to see if it is feasible to come up with a submarine that will do all those things that the CNO wants it to do. Can we build it, can we afford it—two things.

Out of the conceptual design studies comes the outline of the submarine. I have another model that shows you how that evolves as you go through the design process.

Senator DOMENICI. Let me just stop you for a minute. What you are really saying is consistent with maximizing our technological capacity in that it evolves by evaluation of our adversary versus what we have and a desire to improve it?

Admiral McKEE. Yes, sir.

Senator DOMENICI. We have no just general research program on submarine technology that is always pushing us to the extreme of better submarines? It is this kind of an effort that does that?

Admiral McKEE. It is a combination of the two, Senator. There are research and development efforts in submarines that are going on all the time, and we reach into those—in combat systems, materials—and where we can use them to improve an existing class, we will.

Where we have to go to the next class, we do.

Senator DOMENICI. I understand.

Thank you, Mr. Chairman.

Senator JOHNSTON. Senator, thank you.

Senator Cochran?

Senator COCHRAN. I have asked the question I had.

What is going to be in the budget request for us to approve here in our subcommittee?

BUDGET REQUEST FOR 1988

Admiral McKEE. Today, I am here for the DOE budget, and that request is for $612 million, of which approximately $100 million is to do this, and the rest is devoted to running my program and supporting the operating fleet and the research and development effort of the Department of Energy.

Senator Cochran. Is that enough?

Admiral McKee. Yes, sir; that is enough to do my work. And you will see other requests from the Navy. I think the number for research and development for the Navy's SSN-21 program is $213 million. A total of $213 million plus the combat systems which is something on the order of $210 million; but you will see those in the Navy budget.

SUBMARINE NUMBERING

Senator Johnston. Just two very quick questions.

First, there is no sense in these numbers—688 and 21—other than 21st century. What is the 688?

Admiral McKee. The number 688 is just the first of the line. The *Nautilus* was 571. Every time we put a new boat in, it gets a higher number. The *Baton Rouge* was 689; 690 was *Philadelphia*, and so forth. The number 21 is a gimmick.

Senator Johnston. Are these other numbers a gimmick?

Admiral McKee. The name 21 is simply a gimmick. They thought we ought to have some sort of buzzy term for it since it is going to be the submarine of the 21st century. So, we call it SSN-21; but when we built it, it will probably be assigned a sequential hull number.

NUCLEAR ATTACK ON SUBMARINES

Senator Johnston. Now, let me ask you one final question. I have heard it said by a very serious scientist—very serious—that there could be a threat against our submarines by saturation of nuclear weapons in the seas. They wouldn't know exactly where they were, but just saturate the seas. What is your response to that possible threat?

Admiral McKee. [Deleted.]

[Deleted.]

Senator Johnston. Admiral McKee, thank you very much. I think you can see that we are all submariners on this panel.

Admiral McKee. Yes, sir. [Laughter.]

Senator Johnston. If you haven't been out with Admiral McKee, you ought to go out to sea with him.

Senator Domenici. I haven't, but I have been on the *Albuquerque*.

Admiral McKee. Good for you. Senator Cochran needs a ride.

Senator Cochran. No; I have been there.

Admiral McKee. Oh, that is right; you have.

Senator Johnston. But you haven't been on the *Trident*.

Senator Cochran. We will have to work on that.

Admiral McKee. You should really take that ride.

Senator McClure. It is still available, isn't it?

Admiral McKee. Yes, sir.

Senator Johnston. Thank you, Admiral McKee.

Admiral McKee. Yes, sir.

[A brief recess was taken.]

NATIONAL WEAPONS LABORATORIES OVERVIEW

STATEMENT OF DON OFTE, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

Senator JOHNSTON. Gentlemen, we welcome each of you. We are very pleased this afternoon to welcome to the committee three outstanding directors, witnesses, and scientists. These are the Directors and President of our nuclear weapons laboratories: Dr. Roger Batzel, Director of the Lawrence Livermore National Laboratory; Dr. Siegfried Hecker, Director of the Los Alamos National Laboratory; and Dr. Irwin Welber, President of Sandia National Laboratories.

Gentlemen, the labs which you three represent are vital, of course, to our national defense and to the nation. Your labs are real centers of excellence, as far as I am concerned, and I am sure as far as this committee is concerned.

We would like to hear from you today about what you are doing, what your needs are; and frankly, I would like to hear about what you think the possibilities are for other areas of endeavor of the labs.

I have been frustrated from time to time in seeing various programs not run well by other agencies of the government.

We have just returned, I might add, from Sweden and France, where we have seen a nuclear waste program in those countries undertaken at a fraction of the cost, with at least as high a degree of safety—at least as high ~~a~~ degree of safety—as I think we are going to have in this country.

And I see that we have the scientific resources—we have the expertise. We invented most of the programs, most of the technologies—that is just one example; I could go into other examples as well.

So, I would like to see a broader charter, frankly, for our national labs. I hope that doesn't disappoint you too badly. [Laughter.]

I would like to see a broader charter for our labs, because I really am a supporter of the labs and all that you do.

So, with that, Dr. Batzel, you have seniority, why don't you begin.

Dr. BATZEL. We have Don Ofte with us, too.

Senator JOHNSTON. Excuse me.

PROGRAM OVERVIEW

Mr. OFTE. This morning, as we were discussing coming over here this afternoon, we thought it would be useful if I just spent a couple of minutes at the outset to put into perspective where the laboratories fit within the overall financial situation in Defense programs this year.

Admiral Foley would be here to do it, but he had a death in the family and had to go to Pennsylvania. He will be here tomorrow to appear, sir.

DEFENSE PROGRAMS
FY 1988/1989 CONGRESSIONAL REQUEST
(DOLLARS IN MILLIONS)

	FY 86 APPROP	FY 87 APPROP	FY 88 REQUEST	FY 89 REQUEST
WEAPONS ACTIVITIES	$4,177	$4,181	$4,535	$4,606
NUCLEAR MATERIALS PRODUCTION	1,768	1,858	1,882	2,220
DEFENSE WASTE & TRANS. MGMT.	618	672	811	771
SECURITY AFFAIRS	186	194	210	255
DEFENSE PROGRAMS	$6,749	$6,905	$7,438	$7,852
			+7.7%	+5.6%

Mr. OFTE. The overall request that is before the Congress now for fiscal year 1988 is $7.4 billion, an increase of 7.7 percent, 3.7 percent real growth from last year.

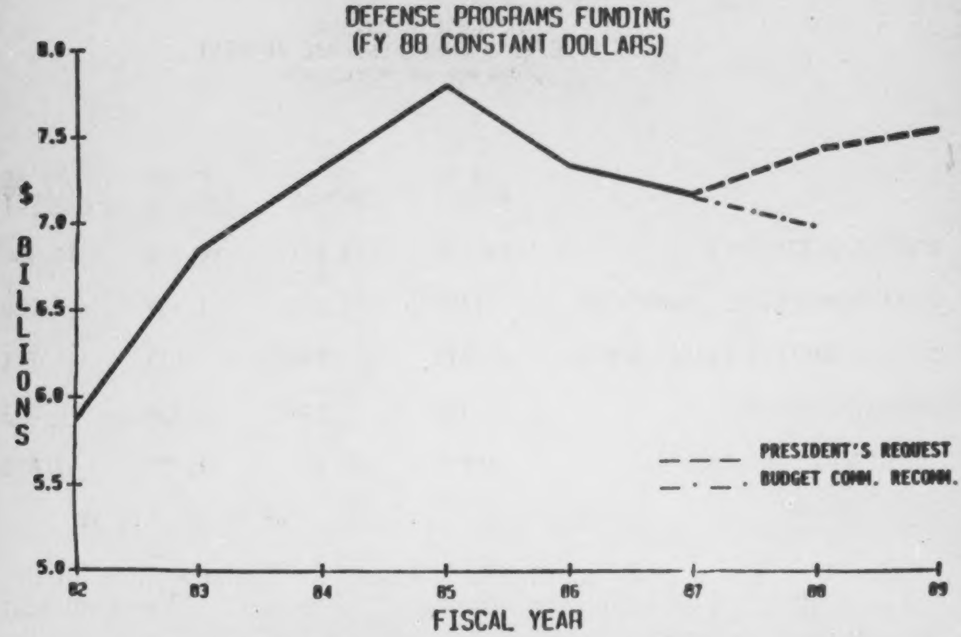
The weapons laboratories' program activity takes place in that top line—weapons activities—so, in the next chart, we will break that down and then reflect on it.

SUMMARY TABLE
(DOLLARS IN MILLICNS)

	FY 1986 ACTUAL	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
RESEARCH AND DEVELOPMENT	$1,198.5	$1,230.6	$1,397.5	$1,411.1
TESTING	588.8	619.7	690.0	656.8
PRODUCTION AND SURVEILLANCE	2,287.4	2,261.1	2,372.4	2,460.5
PROGRAM DIRECTION	102.7	69.8	74.8	77.8
TOTAL WEAPONS ACTIVITIES	$4,177.4	$4,181.2	$4,534.7	$4,606.2

Mr. OFTE. In those two top categories—research and development and then the testing line below that—in aggregate those are the budgets that are assigned to our three laboratories.

Production and surveillance is the Albuquerque account for the production activities that take place throughout the weapons complex, and program direction—that last line—that is what pays the government employees' salaries and other expenses associated with the federal activities.



Mr. Ofte. That is the request as it has come over to the Congress.

When we look at trends, we see very clearly that fiscal year 1985 was the peak year for funding in this program. The dotted line to the right in 1988 and 1989—the upper line—represents our 1988 and 1989 request.

Senator Johnston. What is the increase—in that principal part of the increase?

Mr. Ofte. The principal part of the increase is inflation, SDI, some restoration activities, and environmental, safety, and health activities.

Senator Johnston. Can you give us about how much is it for each program?

Mr. Ofte. I don't have that information here today but tomorrow Admiral Foley will be going through that in great detail.

Senator Johnston. All right, proceed.

Mr. Ofte. The lower line there represents in constant dollars what a flat line—1987 to 1988—would mean to the program and trends.

Static funding levels is something that we have heard from staff members in both chambers now as being a possibility, and that is a very serious consequence for our programs.

FUNDING HISTORY

If we go to the next viewgraph, we can just recap in dollars what has happened to us from the President's request in 1986.

DEFENSE PROGRAMS
BUDGET HISTORY SUMMARY
FY 1985-1988

	FY 1985	FY 1986	FY 1987	FY 1988
PRESIDENT'S REQ.	$7,053	$7,478	$7,636	$7,438
APPROPRIATED	6,825	6,751	6,905	6,905*
DIFFERENCE	$ -228	$ -727	$ -731	$ -533

* BUDGET COMMITTEE RECOMMENDATION BACK TO FY 1987 APPROPRIATED LEVEL.

Mr. OFTE. We were reduced a total in excess of $700 million between congressional action and the Gramm-Rudman-Hollings correction. Our 1987 request was reduced by $731 million. Taking out $1.5 billion over a period of 2 years has taken its toll on the program. We are very thin and we are very fragile.

Senator JOHNSTON. And the hearing tomorrow will cover the specifics in more detail?

Mr. OFTE. Yes, sir; with the consequences of that.

The last column there, that $533 million decrease—we have shared this possibility with the laboratory directors and with our field office managers. We have talked about the types of draconian corrections that we would have to make to meet that kind of a target.

Admiral Foley will discuss more about the impacts tomorrow. The laboratory Directors will be discussing with you today what they see as some of the aspects of that kind of a cut in this year's budget.

Senator JOHNSTON. All right, Dr. Batzel?

Dr. BATZEL. All right, sir.

Senator DOMENICI. Mr. Chairman, before you proceed, might I just make a comment on your opening remarks?

Senator JOHNSTON. Yes, indeed.

ROLE OF THE LABORATORIES

Senator DOMENICI. I am not sure that either you or Senator McClure were there, because it is a different committee—but you raised an issue about the function and role of the National Labs that I would like to address.

When the President of the United States put together his State of the Union message, he included an approach for centers of excellence and competitiveness. The truth of the matter is that the Secretary of Energy, who is essentially the manager of the National Labs, was not even invited to participate in this task.

Thus, you will find not one mention of the National Labs in the proposals on competitiveness set forth by the President in either his general remarks or in his budget increases. You will find no mention of using these labs in any way.

As a matter of fact, they are singularly related to universities and are being tied in with the private sector. We have inquired in our state why one of the labs wouldn't be a natural partner, either in your state or our state or Senator McClure's state, and a center of excellence placed there, because that is all done through the National Science Foundation and Dr. Bloch.

It seems incredible to me, and I really appreciate your question, that this government is going to proceed through this era of trying to find competitive capability to use its resources and pool them—and we are not including the National Labs that I am aware of, other than where they may have an ongoing program.

They are good at something, so they are doing it as part of the Department of Energy's nondefense work.

I believe it is a tremendous waste of national resources if we don't figure out some way to get these labs involved in that process.

Now, we have heard a lot about problems related to computer chips and what may be a lag in terms of our keeping up with the Japanese.

Would you believe that the Department of Defense did an in-depth study on our continued reliance upon importing computer chips from Japan for the Defense Department? And they came up with a brilliant set of recommendations.

I happen to know that the second to last draft of the proposals—because we want to have some consortiums to center our research—mentions centers of excellence with the private sector, Defense Department funding, universities, and laboratories.

By the time the final draft came to presentation, the labs were left out. It just seems to me that we have a very serious problem in terms of what these labs should be doing because they are tremendous centers of multiple disciplines, and we ought to be using them.

I will tell you, from the standpoint of Sandia and Los Alamos—starting back 3 or 4 months ago—I asked them if they would consider the very question that you have asked; and I am sure you have been doing the same.

But they do have some exciting ideas on their utility as part of amassing our resources in this very competitive world, especially when we are competing with integrated-type companies in Japan.

I mean, if you look at the largest computer chip company in the world, it is Nekgem in Japan. You can hardly find it in the outline of the corporation, that is the Japanese corporation, of which it is a part.

I mean, it is an automobile company. It is a steel mill. It is 15 other major companies. And here sits the largest semiconductor company in the world, integrated this way and that way; and we don't even have our labs involved in helping our private sector with the research.

I don't know what the strange attitude is between the private sector and universities; but sooner or later, all three have to get together, it seems to me.

I just wanted to share that with you. And I am sure Senator McClure has been concerned.

BASIC RESEARCH EFFORTS

I would also say I am very concerned about our basic research dollars. We don't have enough, and we have got to consider the Supercollider, for example. I am for it; it is a great machine. And we have other initiatives on the horizon.

What I am afraid of is that we are going to proliferate our money into areas that are not primary, thinking they are basic science, and end up shortchanging our capabilities in the labs and elsewhere.

Frankly, credibility is a difficult commodity to come by in advice to the Congress, and I think the labs have it, and that it is very valuable to us and very valuable to the country.

Senator McCLURE. Mr. Chairman?

Senator JOHNSTON. Senator McClure?

Senator McCLURE. I agree with what both of you have said, and I would suggest that, if we really want to get into that—and I think it is worth getting into—we ought to set up a hearing that is devoted to doing that and then bring in some other people in addition to those who are here, or other instruments of the government like OTA that ought to be included in that kind of an assessment.

I think it is well worth a much broader inquiry than just asking a few ad hoc questions this afternoon, as important as this group is.

Senator DOMENICI. And Mr. Chairman, I did not see the Senator from Tennessee walk in, but whenever I mentioned labs, I certainly did not intend to leave out Oak Ridge.

As a matter of fact, Oak Ridge has written some very profound articles on the computer issue and how the labs ought to be helpful with reference to the computer chip, other current problems, and long-range research.

Senator McClure is probably right. It takes an awful lot more than just this hearing. Thank you very much.

Senator JOHNSTON. Let the record reflect that Senator Sasser, if queried about Oak Ridge, would say it is a very good lab.

Senator SASSER. Oh, absolutely. [Laughter.]

I always let Senator Domenici have the last word. Thank you. [Laughter.]

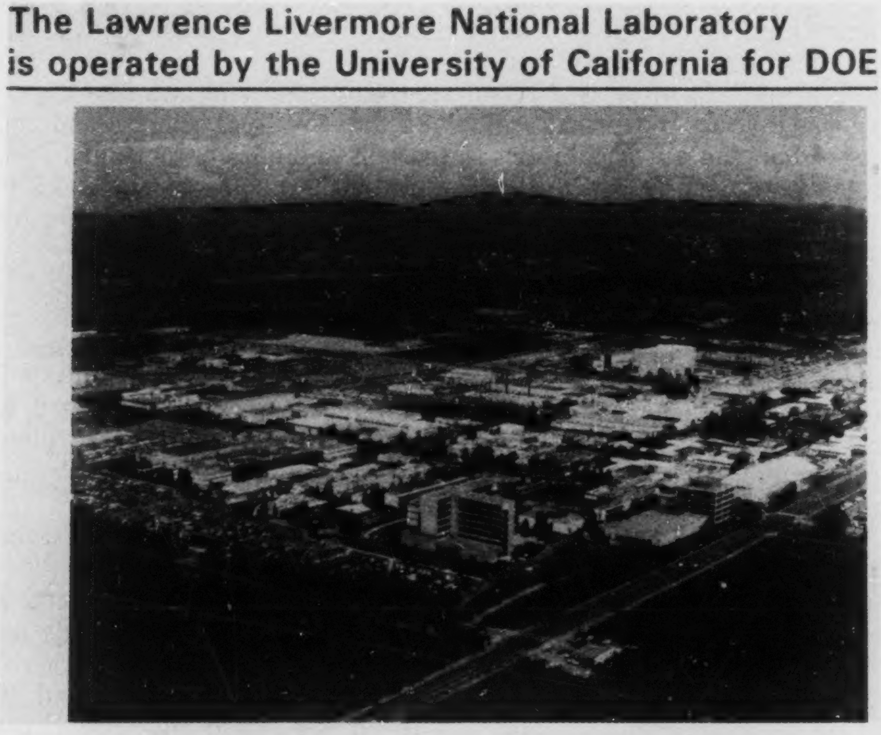
Senator JOHNSTON. Dr. Batzel?

ROLE OF LAWRENCE LIVERMORE NATIONAL LABORATORY

STATEMENT OF DR. ROGER E. BATZEL, DIRECTOR, LAWRENCE LIVERMORE NATIONAL LABORATORY

Dr. BATZEL. I certainly appreciate the opportunity to appear before you today to talk about the role of the national laboratories. Specifically, I will start with the Lawrence Livermore National Laboratory, which I represent, but I do intend to discuss the issue of competitiveness and how the laboratories—at least the laboratories represented here might contribute in that kind of an area.

Eighty percent of our funding is appropriated by this Energy and Water Subcommittee; the interest of this subcommittee is highly important to us obviously.



The Lawrence Livermore National Laboratory is operated by the University of California for DOE

Dr. BATZEL. This is a viewgraph showing the Lawrence Livermore National Laboratory. It is a multiprogram, multidisciplinary laboratory, and our efforts range from mostly defense to the environment.

The laboratory is operated by the University of California under contract with the Department of Energy. We do work for the government; in other words, for the Department of Energy, for the Department of Defense, and sometimes state organizations, also.

Lawrence Livermore National Laboratory

- **Founded in 1952 by E. O. Lawrence**
- **One of two nuclear weapon development laboratories**
- **Mission is research and development on nuclear weapon, energy and national security problems**
- **8090 full-time-equivalent employees**
- **Operating budget $0.8 Billion in FY 1986**

The laboratory was founded in 1952 by Ernest Lawrence and others, and it is one of the two nuclear weapons research and development laboratories. Of course, Los Alamos was the original.

We have a unique responsibility to the country in nuclear weapons research and development. It is a technology which does not exist outside those two laboratories; therefore, I think it is especially important that the stability of these laboratories be guaranteed for the future.

When the laboratory was founded, it was founded as a national research institute or institution. The Atomic Energy Act established independent civilian control of atomic energy and the AEC was able to establish at that time a unique arrangement with the universities and industry which contracted for operation of those laboratories.

That is a legacy of which we are very proud.

MAJOR PROGRAMS AT LLNL

To give you a breakdown of the distribution of effort within the laboratory, essentially 80 percent of our effort is defense related.

Energy research, nuclear energy, other activities include a number of areas; for example, we are involved in a significant way in the waste disposal effort in conjunction with the characterization of the Yucca Mountain in Nevada, a potential repository.

Our activities include a wide spectrum of efforts today. We really think that is one of the reasons we are here—to take on the tough problems which the country faces and where we have a unique capability to take it on.

NUCLEAR WASTE DISPOSAL SITE CHARACTERIZATION

Senator JOHNSTON. That is directly under DOE that you are involved with the characterization of the Yucca Mountains?

Dr. BATZEL. Yes; we are. It is a significant effort; not a large effort. It is approximately $15 million a year.

Senator JOHNSTON. Let me digress on that. Are there any problems with that site that you know about at this point?

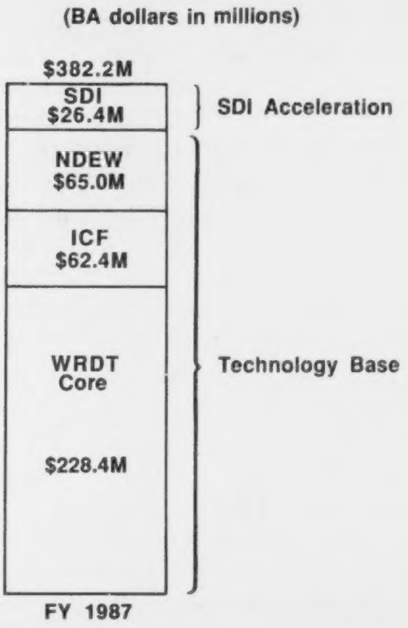
Dr. BATZEL. Not that I know about. The laboratory's involvement in the geological characterization has been limited. We have been working on the configuration for the fuel rods and containers; for example, specific to that particular site.

Nuclear weapons research and development is the reason we exist. At least for the foreseeable future, we expect nuclear weapons research to be the major contribution that the laboratory will make to the country.

IMPORTANCE OF LABORATORY'S TECHNOLOGY BASE

It is the core program for the laboratory. When you have ups and downs in that particular area, it causes difficulties for the laboratory as a whole because nuclear weapons research is the fundamental base on which the laboratory is built.

The WRD&T technology base includes many pieces



Dr. BATZEL. The weapons research and development and test technology base includes a number of pieces.

There is what we call the core. The core program has to do with the technology base for nuclear weapons. As I say, that technology does not exist outside of the two laboratories.

Senator JOHNSTON. WRDT stands for?

Dr. BATZEL. Weapons research, development, and test.

Senator JOHNSTON. And ICF?

Dr. BATZEL. Is inertial confinement fusion. We view that as a part of the core program. The part nuclear-directed energy of the nuclear weapons research was ongoing before the SDI organization was formed.

Senator JOHNSTON. Laser fusion?

Dr. BATZEL. The ICF is laser fusion. The nuclear directed energy weapons-related portion is the SDI-related effort. There is a part of NDEW which we would characterize as acceleration. In other words, response to the SDI organization's willingness to put additional resources into that area to meet their milestones.

Senator JOHNSTON. And NDEW is essentially your x ray laser and your free electron?

Dr. BATZEL. The Free Electron Laser is separate and distinct from that. It appears under the work we do for the Department of Defense, over and above that, separate from that.

The point I am trying to make here is that there is a technology base. When one looks at nuclear-directed energy weapons or the SDI effort, one has to recognize that a lot of that is base technology work which was ongoing before SDI was formed.

So, when you take a look at a reduction in that particular area, one has to remember that you are cutting the core capability for the laboratory. One wants to keep that in mind.

Senator JOHNSTON. When you cut what?

Dr. BATZEL. When you cut NDEW, which is SDI related—you have to recognize that that is part of our technology base. So, when you cut that, be careful that you understand that it is just like cutting some of the guts out of the laboratory—not all of it, but an important part.

Part of the NDEW effort has to do with our response to acceleration of that program, for example. Not that that isn't justified, but it isn't something we would have done in the normal course of our weapons research and development in an ongoing program.

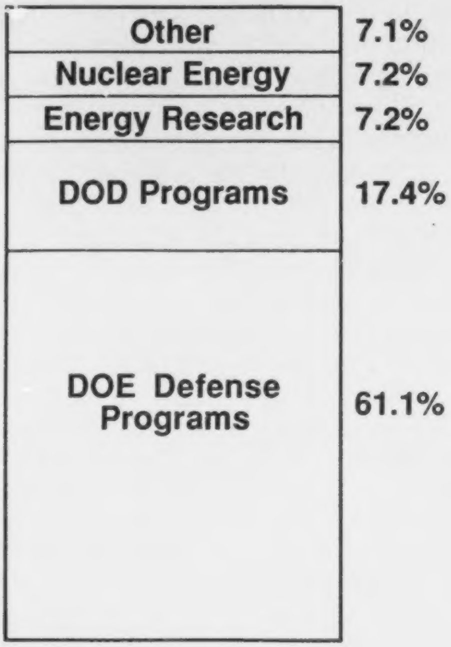
The issue as far as we are concerned for the 1988 period has to do with the fact that we really believe we need something very close to the President's budget in order to maintain that core viability for the program.

Again, that is an important area for us. There is another area which I should address at the same time—the special isotope separation work which we are doing which is the laser isotope separation work in support of the plutonium cleanup. We think that is an important flexibility for the country to have.

So, we really support that as an effort for the country.

Lawrence Livermore National Laboratory Major Programs

Distribution of Laboratory staff effort – 8250 FTEs



LABORATORY MISSION AND ROLE

Dr. BATZEL. Now, I want to speak to the issue of the laboratory and its mission. We are supposed to function as a national resource of scientific and technical capability and, as appropriate, for other programs of national importance.

That follows up on your comments that we feel we should be available to take on other programs and other issues.

LLNL's National Security role

LLNL's primary mission is to provide the nation a nuclear deterrent that will preserve world peace

Defense Programs has four major goals

- **assure that the weapons in the nation's nuclear arsenal are safe and reliable**
- **develop options for replacing aging weapons with modern military systems**
- **develop improved safety and security features for nuclear weapons**
- **guard against technical surprise in new weapons concepts**

Lawrence Livermore National Laboratory
Mission and Roles

Mission

Our mission is to function as a national resource of scientific and technical capability for the nation's defense programs and, as appropriate, for other programs of national interest.

Roles

Our primary role is to perform the research, development, and testing associated with the nuclear design aspects of all phases of the nuclear weapon life cycle, and perform associated national security related tasks.

We have a corollary role to address other important national problems. Within this role, the Laboratory has developed several areas of scientific and technical excellence and long-term commitment: inertial fusion, magnetic fusion, biomedical and environmental research, isotope separation, applied energy technology, and other related research activities.

Dr. BATZEL. Again, our primary role is that of nuclear weapons research and development, and we address all of the aspects of the nuclear weapons technology from concept through development and deployment into the stockpile.

It is clear that our major responsibility and first commitment is to national security, but we do believe we are in a position to take on other major programs.

In defense programs, we have four major goals: to assure that the weapons in the nation's nuclear arsenal are safe and reliable; to develop options for replacing aging weapons with modern military systems; to improve safety and security; and to guard against technical surprises.

In large measure, the country's nuclear weapons capability, again as I emphasized, depends on the excellence of the two nuclear weapons research and development laboratories.

We must not forget that there are other players in this game out there.

[Chart deleted.]

SOVIET NUCLEAR WEAPONS FACILITIES

Dr. BATZEL. [Deleted.]

They have a very active test program. They are good people; so the competition is there. We should not forget that.

LABORATORY CONTRIBUTIONS TO U.S. INDUSTRIAL COMPETITIVENESS

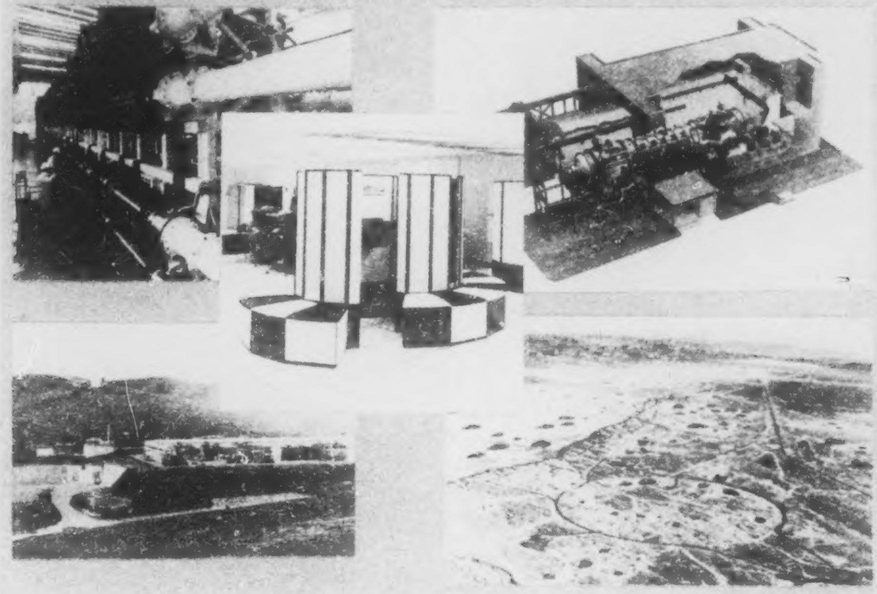
Dr. BATZEL. Now, I want to switch to the issue of competitiveness. When the laboratory was founded, and in fact, until about 1972, it was rather clear that the United States had a competitive edge over most of the rest of the world. That is no longer the case.

There are many other countries which surpass the United States in key technology development. Not that the United States can't take that on and develop it, but there are many areas around the world where one finds capabilities which just plain don't exist in the United States.

In these large program laboratories, we have the opportunity to make additional contributions, and the question is how to do that.

I will discuss a couple of areas in which we have been involved and made some significant contributions.

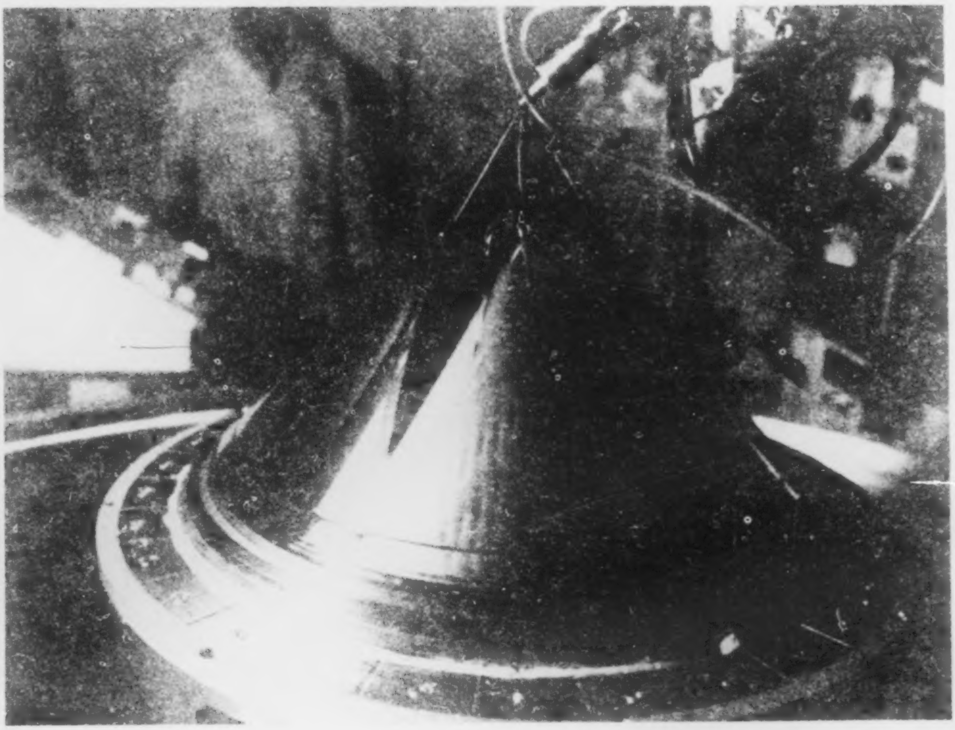
Lawrence Livermore National Laboratory
The Mathematical Modeling of Physical Phenomena



Dr. BATZEL. This is the issue of computers, supercomputers. The laboratories historically have driven the supercomputer industry to provide major, large computers in order to model the kinds of activities and processes with which we deal.

As you know, we do our nuclear experiments at the Nevada Test Site. We deal in timeframes and physical systems which we just can't reproduce in the laboratory at all. We have to have the large computers.

So, the laboratories have made major contributions to the development of what is called software for the utilization of those major computers. We really see that as an area where we can continue to contribute.



Another example has to do with what we call precision engineering which is in conjunction with the weapons program. We have had the necessity to be able to machine parts to very high precision.

This is done by using what we call diamond turning machines, which actually use diamonds as cutting tools. We developed this technology.

This is an example of a 15-by-15-inch-high cone which is machined to a precision of microinches—millionths of an inch—in fact, a fraction of a millionth of an inch.

That kind of precision is useful in our industry for laser optical parts, even for molds for plastic contact lenses, computer memory disks, photocopier cylinders, video tape recorders, cameras, and so forth. That is another example.

COMMERCIALIZATION OF LABORATORY TECHNOLOGY

Dr. BATZEL. There are changes which could be made to assist the commercialization of the laboratory technologies.

A few changes will significantly assist commercialization of Laboratory technologies

- **Full implementation of Stevenson-Wydler and Bayh-Dole Bills.**
- **Right to elect title to all unclassified and non-sensitive technologies at the Laboratories, including patents, copyrights, technical data, and property such as biological cell lines.**
- **Elimination of DOE added cost factor for industrial sponsors.**
- **Elimination of reimbursement by University, to Government, of waived patent costs.**
- **New flexibility to enter into cooperative R&D agreements with industry.**

No. 1 is the full implementation of Stevenson-Wydler; that is, the Technology Transfer Act, and the Bayh-Dole bill which is in the patent area.

The question of right to title to all unclassified and nonsensitive technologies at the laboratories has to do with the fact that patents are important.They are important to the organization itself, to the laboratories, and to the universities in the case of its two weapons laboratories.

There is a Department of Energy added cost factor, which is full cost recovery, which could be waived.

Then, the university has to pay for government costs to actually get title to the patents. We really need flexibility to enter into cooperative R&D agreements with industry.

That is a significant area. It is an area which we are pushing. We have had some success. We certainly need to do more.

A MANAGEMENT PARTNERSHIP

Dr. Batzel. Another major issue for the laboratory is the management contract. It is interesting, when one looks at what Contract 48 says. That is the contract between the Department of Energy and the University of California for the operation of the Lawrence Livermore National Laboratory.

These are separate but virtually common contracts for Los Alamos and ourselves.

It is interesting to say that it is the intent of the DOE and the university that this agreement shall be carried on in the spirit of friendly cooperation with a maximum of effort and common sense.

Senator JOHNSTON. Is that an enforceable contract? [Laughter.]

We ought to build that into every government document, if it is. [Laughter.]

Dr. BATZEL. I sure hope it is. It is the one under which we are operating. But, nevertheless, it is clearly important that there be a commonsense arrangement where we are able to interact with people at the Washington level and they are able to interact with us in a positive way.

LABORATORY ACCESS TO CONGRESS

Senator JOHNSTON. Let me digress a moment there.

I have stated before that it will be our purpose—and I don't know whether we can do it or not—to put an amendment in our appropriations bill to guarantee access of the labs to Congress, which we are a little bit concerned about.

Is that a good idea?

Dr. BATZEL. We need access to you, for sure.

Senator JOHNSTON. Would anyone disagree with that?

Senator MCCLURE. I knew an alarm would go off. [Laughter.]

That must be Admiral Foley. [Laughter.]

Dr. HECKER. I guess my opinion on that is that we certainly need, in these times of technological complexity, a dialog between Congress and the technological arms of the country. I think the labs are one of those, and we need to encourage that dialog.

Senator JOHNSTON. We will try to build in some language on that. Excuse me for interrupting.

Dr. BATZEL. That is fine. It is clear that it is issues like that that need to be worked to keep the commonsense arrangement in place.

It is also important to remember that the AEC did put primary emphasis on program objectives. One gets the feeling these days that people lose sight of the program objectives and worry about the bureaucratic structure more than accomplishment of program.

I think that has to be worried through.

The Department of Energy really does run a high technology effort; and again, for the laboratories to do their job and do it well, we need people at the Washington level with whom we can interact in a very positive way.

I think within its defense programs, the Department of Energy has done a very good job historically over the years. But clearly, this is a challenge to all of us to make sure that there are people at the Washington level who are able to make program decisions and able to evaluate programmatic efforts, not just bureaucratic accomplishments.

CONFLICT OF INTEREST

Now, the question is: Does one need to restructure in any way the system within which we operate? Conflict of interest turns out to be one of those issues which keeps some good people away from government. It is very difficult for them to return to related activities once they leave the government.

That keeps many potentially very good people out of the system. It seems to me we ought to figure out a way of working that kind of problem so that there can be an understanding that, when they come in, they haven't precluded, for example, their ability to return to their area of expertise and use their experience.

APPLICATION OF CIVIL SERVICE REGULATIONS

Another issue which was important to the AEC and ERDA was what was called an excepted status, which meant that they did not have to operate within the civil service function. They had flexibility to keep good people on their payrolls and remove them as needed, rather than having a complex bureaucratic structure within which to operate.

So, those are a couple of possibilities for ways of increasing the possibility that the Department of Energy can continue to get people and get even better people than they have at the Washington level.

As far as the future of the national laboratories is concerned, I believe the national laboratories, in particular these three laboratories, are special, but we cannot fulfill our roles by ourselves.

If we are going to achieve what is best for the nation, we must have a partnership with the federal government.

I want to emphasize again the commitment we really feel to national defense and national security. However, the future of the laboratory does depend on our ability to get the excellent people and to provide a stable structure within which to operate.

We can't afford to be bouncing up and down as the situation changes. So, we need to help and we need your help in providing a structure within which the laboratories can continue to do the job they are responsible for and to take on new areas of responsibility as needed.

Thank you.

Senator JOHNSTON. Thank you, Dr. Batzel, and I would certainly agree with that. As old responsibilities fade out, with or without our agreement on this committee—we may disagree with some responsibilities and someone else may fade out—we will look for other areas for the labs to get into so that you will have that stability of program and employment, as we mentioned earlier.

Now, we will turn to the Los Alamos National Laboratory and Dr. Hecker.

STATEMENT OF DR. SIEGFRIED S. HECKER, DIRECTOR, LOS ALAMOS NATIONAL LABORATORY

Dr. HECKER. Thank you, Mr. Chairman. It is also my pleasure to appear in front of this subcommittee. Roger pointed out the role of the laboratory in the nuclear weapons technology arena.

I would like to tie that to their importance as far as national deterrence is concerned.

ROLE OF LABORATORIES

We certainly all recognize the importance of nuclear weapons technology in the nation's nuclear deterrent. The theme that I would like to bring across today is to show just how critical the laboratories are in maintaining a credible deterrent.

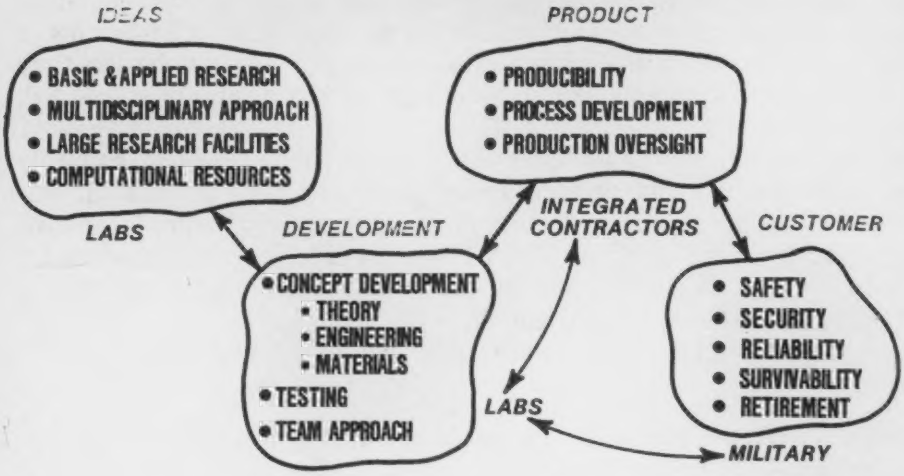
Then, I will address the budgetary impacts on the Los Alamos National Laboratory.

From the standpoint of setting the framework in terms of deterrence, of course what we all must remember is that deterrence is indeed dynamic and that it changes with a number of different factors, such as the actual force structure, the initiatives in terms of arms control, deployment strategy, and certainly such actions as protective actions or evasive actions by the Soviets, such as hardening, burying, or using relocatable missiles. All of this changes the picture of deterrence.

The real key to be able to maintain a credible deterrent is to be able to accommodate those changes, to respond to those changes. I think that is the real role that the laboratories play from a technical standpoint; that is, the ability to respond and the ability to accommodate those changes.

The responsibility that we have, as Roger has alluded to in nuclear weapons technology, is over a very broad range of activities.

DOE WEAPONS LABS HAVE RESPONSIBILITY FOR NUCLEAR WEAPON TECHNOLOGY FROM BASIC RESEARCH TO WEAPON RETIREMENT


IDEAS
PRODUCT
• BASIC & APPLIED RESEARCH
• MULTIDISCIPLINARY APPROACH
• LARGE RESEARCH FACILITIES
• COMPUTATIONAL RESOURCES
• PRODUCIBILITY
• PROCESS DEVELOPMENT
• PRODUCTION OVERSIGHT
LABS
DEVELOPMENT
INTEGRATED CONTRACTORS
CUSTOMER
• CONCEPT DEVELOPMENT
• THEORY
• ENGINEERING
• MATERIALS
• TESTING
• TEAM APPROACH
• SAFETY
• SECURITY
• RELIABILITY
• SURVIVABILITY
• RETIREMENT
LABS
MILITARY

Los Alamos

I would like to give you a picture of just how broad that responsibility is. It spans both the generation of initial ideas to the development of those ideas to a product, and then to the interactions with the customer.

If I may just say a few words about those different areas. In the ideas area, of course, there is a need for basic research. What we do particularly well at the national laboratories, the weapons laboratories specifically, is to be able to do it in a multidisciplinary fashion; that is, to bring to bear the capabilities in areas such as physics, chemistry, materials, mathematics—some of these very complex problems.

We also have very large research facilities, and we have enormous computational capability. The important point to make, as far as ideas or the generation of ideas goes from the standpoint of weapons laboratories and nuclear weapons particularly, is the fact that we have to generate that basic research.

There isn't a university sector that generates ideas for research for nuclear weapons. So it is really the laboratories that have that responsibility—to do basic research.

In addition to that, the only way, in my opinion, that you can have real scientific vitality in an institution is to be able to do research at the forefront.

From the development standpoint, of course, we don't have to develop those ideas into concepts. And there, we are able to marry theory, engineering, and materials, to develop those ideas into real concepts.

Of course, testing is very important, both from a standpoint of the local tests that we run at Los Alamos and the tests at the Nevada Test Site.

Approximately a month ago in your hearing, you discussed the importance of testing to the overall nuclear weapons program. I can only say that that importance cannot be overemphasized.

Additionally, what we are really able to offer at the national laboratories is a team approach in being able to solve problems. You not only need to have the individual creativity of scientists; but in order to get this job done, you have to be able to field a team and rapidly move in a direction of being able to develop a concept.

This is done at the laboratories. Of course, we don't do the production at the laboratories; that is done at the system of integrated contractors.

However, we interface very closely with them there. We don't just send them the blueprints and say, "Good luck; make these things."

We have to work with them from the standpoint of producibility of these designs. Are these designs really producible? We work with them on process development. Can we really work with them on the different processes that it takes to make these weapons?

And then, we have general production oversight. When that is given to the customer—the customer is the military—again, our responsibilities include the interaction with the customer.

There we have the responsibilities for safety, security, reliability, survivability of the weapons. We are also involved in the very final stage which is the retirement of the weapons.

And so, the point that I would like to emphasize here is that this very broad range of responsibilities is all within one of the three laboratories combined. This concept is very unusual in today's world.

There are very few places, either in the rest of the defense complex or in private industry, where you find the ability of an institution to take it all the way from a basic research idea to the final product with the oversight and interaction.

TECHNOLOGY TRANSFER

In fact, it is the fact that the laboratories have done this since their inception that really gives us the appropriate leg up in the area of technology transfer. It is, in my opinion, one of the best examples you will ever see of technology transfer.

We create the idea and we usher the product all the way through; and we worry about its retirement.

I have shown it to you for the case where we work in the nuclear weapons arena. However, even in the nonnuclear weapons arena—let's say either the DOD or in the private sector—the sort of culture and capability that we have set up at these laboratories gives one the ability to get around many of the current problems in technology transfer. And that is: How do you take an idea from research—which I think this country does extremely well—and make a product out of that?

Obviously, in the private sector we don't do the product side and the customer side. I mean, that is industry's job to do, but that interface of trying to bring an idea all the way through and working with the customer is one that we do well at the laboratories.

It is one where I think the laboratories can make a substantial contribution to the question of technology development in this country.

To a large extent, that holds, in my opinion, for all the DOE multiprogram national laboratories. It holds especially for the weapons laboratories because of the fact that we do have to worry about a product and the customer interface.

IMPORTANCE OF ADEQUATE FUNDING

The other point that I want to make with that particular chart is that when you fund a laboratory, what you are really funding is that integrated capability. It is that capability that really maintains deterrence, in my opinion.

One shouldn't look at funding the laboratories as a procurement of any single box on that chart or any single military system; but it is the procurement of the entire integrated capability.

Because of the strong support that we have gotten from Congress, and particularly this committee, over the years, we have been able to build the laboratories—as Roger said—into what we consider a national resource for science and technology.

LABORATORY MISSION

Let me turn to Los Alamos specifically. Los Alamos National Laboratory, as Livermore National Laboratory, is run by the University of California. We are located in the mountains of New Mexico on a site about 43 square miles close to Santa Fe.

LABORATORY MISSION

- OUR PRIMARY MISSION IS TO APPLY SCIENTIFIC AND ENGINEERING CAPABILITIES TO ASSURE THE NATION'S DETERRENT THROUGH NUCLEAR WEAPONS TECHNOLOGY

- TO BE RESPONSIVE TO NATIONAL NEEDS AND TO SUCCEED IN THIS PRIMARY MISSION, WE:
  - STRONGLY SUPPORT BASIC RESEARCH IN SELECTED DISCIPLINES TO HELP MAINTAIN AN OUTSTANDING SCIENCE AND TECHNOLOGY BASE
  - CONDUCT OTHER APPLIED PROGRAMS, PRIMARILY IN DEFENSE AND ENERGY, THAT COMPLEMENT THE PRIMARY MISSION
  - ENCOURAGE NEW IDEAS THAT FIT THE LONG-TERM VISION OF A MULTIDISCIPLINARY LABORATORY SOLVING PROBLEMS OF NATIONAL IMPORTANCE

Los Alamos

The Management Contract at LLNL

"It is the purpose of this agreement to encourage basic scientific progress and to assure adequate technical accomplishment in the interest of the national defense and public welfare. It is expressly understood that this agreement is subject to the paramount objective of assuring the common defense and security of the United States.

It is the intent of the DOE and University that this agreement shall be carried on in a spirit of friendly cooperation with a maximum of effort and common sense in achieving their common objectives."

Source: DOE/LLNL Contract 48

"In developing the concept, AEC put primary emphasis on the achievement of program objectives, while maintaining as much flexibility as possible in the approaches to specific situations."

Source: The Federal Bar Journal
The AEC Management Contract Concept
O. S. Hiestand, Jr. and Mark J. Florsheim

Our origin was with the beginning of the Manhattan Project and the development of the first atomic bomb. We are currently close to 8,000 full-time equivalent employees with a budget of about $840 million in fiscal year 1987.

I have just essentially explained the primary mission of the laboratory. I don't need to go through that again.

The mission of the laboratory is nuclear weapons technology. However, in order to do that mission well, and also to be responsive to more global means—as you mentioned in your introduction—we feel we also need to concentrate on the three subbullets that I have indicated here.

We feel that we absolutely must strongly support basic research, and we do that in selected disciplines that help to maintain an outstanding science and technology base.

We conduct other applied programs; I think in today's world that is particularly important. We are already a multiprogram laboratory involved in a number of other areas.

We need to do that for one fact alone, and that is simply to be able to do the nuclear weapons job properly today.

We have to complement those activities with other work in defense and nondefense.

Then the third one is to encourage new ideas, to make sure that we are responsive to greater national needs—where one needs the multidisciplinary approach of a national laboratory.

LOS ALAMOS PROGRAMS

Let me turn then specifically to give you an idea of the mix of programs that we currently have at the laboratory.

PROGRAMS

DOE/DEFENSE PROGRAMS

- NUCLEAR WEAPONS RD&T
- INERTIAL CONFINEMENT FUSION
- SPECIAL NUCLEAR MATERIALS
- ARMS CONTROL and VERIFICATION
- SAFEGUARDS and SECURITY
- DEFENSE REIMBURSABLES

53.4%

DOE/ENERGY and RESEARCH

- NUCLEAR and PARTICLE PHYSICS
- BASIC ENERGY SCIENCES
- MAGNETIC FUSION ENERGY
- HEALTH and ENVIRONMENTAL RESEARCH
- NUCLEAR ENERGY
- ALTERNATIVE ENERGY

18.4%

DoD

- SDI
- ADVANCED CONVENTIONAL MUNITIONS
- ADVANCED CONCEPTS

INTELLIGENCE

24.1%

REIMBURSABLES

- NUCLEAR REGULATORY COMMISSION
- NATIONAL INSTITUTES OF HEALTH
- NASA
- CENTRAL AMERICA PROJECT
- OTHERS

4.1%

FY 87 OPERATING COSTS $840.1M **Los Alamos**

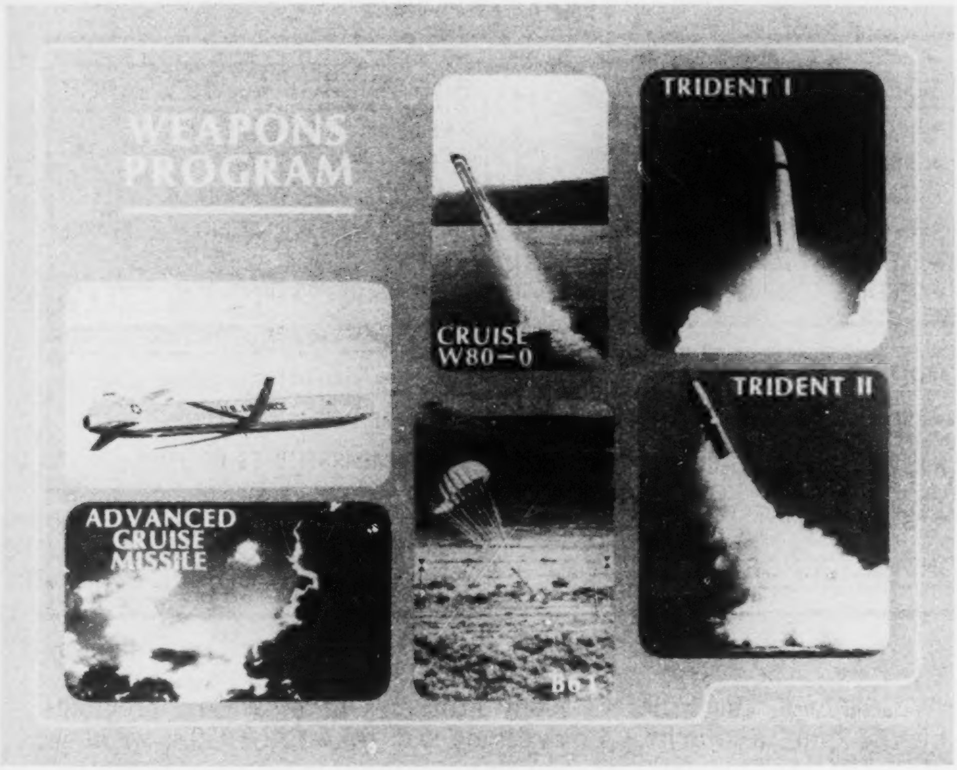
We have on the order of many hundreds of individual programs, which is quite a switch at Los Alamos, say from the 1950's, when we had one. I tried to separate them into major elements so as to try to make it understandable.

The upper left-hand block is what we call the primary mission, that is DOE defense programs, the ones that I have just discussed.

Let me just go through some of the activities.

Nuclear weapons, research, development, and testing is our principal activity. Let me just show the next viewgraph.

I will get back to the charts on our programs eventually.



This chart lists recent programs that Los Alamos has been involved in, and I won't go through any details. The names are all obviously familiar.

Currently, we are still working on the Trident II. That is the phase IV, production engineering phase; and we are still working on the advanced cruise missile.

All the other ones—the B–61 bomb, the cruise missiles, and Trident I—of course, are already in production.

So, we support the stockpile; we support the development at Los Alamos.

In addition we are also involved in inertial confinement fusion. We have a number of activities in special nuclear materials, including processing.

We work in the arms control and verification arena, including verification technology, safeguards and security, and a number of other reimbursables.

I should state here that we work on nuclear-directed energy weapons; it is part of the line that I have shown as nuclear weapons RD&T.

That effort started long before the SDI effort was officially started.

FREE ELECTRON LASERS RESEARCH

Senator JOHNSTON. You are involved with the free electron lasers, aren't you?

Dr. HECKER. In this particular box, what we do is the so-called [deleted] hypervelocity nuclear-directed energy concept and several others. As I mentioned, the SDI in the second box is where we work on the free electron laser.

But in nuclear-driven, we are looking at a number of concepts. The one that we have worked most actively on is the hypervelocity pellet concept.

So, the activity in defense programs is currently only somewhat over half of the laboratory's activity; in that sense, that already makes us a multiprogram laboratory.

We do many other things.

NONMILITARY ACTIVITIES

Senator JOHNSTON. Have you done work on the Central American project?

Dr. HECKER. I beg your pardon?

Senator JOHNSTON. What is the Central American project?

Dr. HECKER. That catches everyone's eye; I will mention that in just a bit.

I guess the first thing I should say though is that it is on the right-hand side, which means it is nonmilitary. If you divide this chart down the center, on the left-hand side we have the defense-related activities. On the lower left is what we do for the Department of Defense directly.

That used to be a reasonably small effort. That has grown substantially in the past 5-year timeframe. Most of that growth has been in the area of nonnuclear SDI.

The two primary concepts that we are pursuing are the neutral particle beam and the free electron laser. We are doing that directly for SDIO.

And let me just give you a bit of the history about how our involvement in that project came to be. As both Roger and I have mentioned, we have the capabilities in science and technology, especially ones that can be applied to very important national problems in the defense arena.

When SDI came along, from the standpoint of research, the importance and the need for research was clear. We had the capabilities, based on both the research and the science and technology base at the laboratory, to be able to step in that arena and to work on an important national problem.

Of course, we are also working in the area of advanced conventional munitions and a variety of other concepts.

The work has gone up to where it is a substantial fraction of the laboratory today. Almost one-fourth of the laboratories' activity is work that we do directly for the Department of Defense.

On the right-hand side is the nondefense work. That currently is somewhat less than 25 percent of the laboratory.

Let me just start out by saying why that right-hand side is extremely important to the laboratory. I feel in any defense institution, if you want to have a first-rate defense institution, you have to have first-rate science as well, and you have to have a nonmilitary component of the activity.

Currently, that nonmilitary component is about as low as it has been at Los Alamos in the past 10 or 15 years.

Senator JOHNSTON. Now, you went over that kind of fast. You said in order to have a good defense installation, you have to have good nonmilitary science as well as military science.Why?

Dr. HECKER. Let me try to elaborate on that. First of all, you have to be able to attract the best of the scientists to work in the defense arena, and you have to have an interaction with the universities that attracts and allows them to interact freely with the universities.

I maintain that the only way you can do that is to have programs that have very high visibility and will keep you at the forefront of science and technology.

Senator JOHNSTON. Like big law firms that have a lot of pro bono work. [Laughter.]

Dr. HECKER. We have to have the programs that serve as a magnet and have the visibility to attract the best of the people to the laboratory.

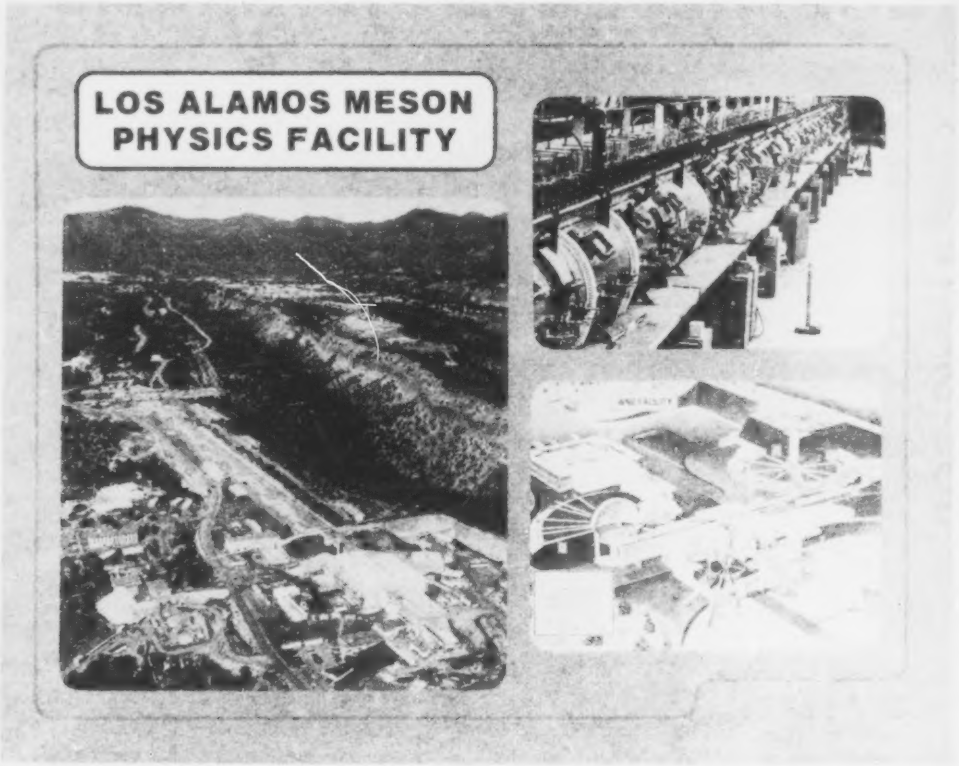
Indeed, I think that is one place where the national laboratories really stand out from the other 720-some federal laboratories that are there, in addition to the DOE national laboratories.

They have been able to preserve a scientific vitality that is very difficult to preserve in the federal laboratory system, and I am not just speaking about the weapons laboratories, but all the DOE multiprogram laboratories.

On the upper right is work we do for DOE's energy and research. In fact, much of that basic research is done in that particular block. There is also much research done on the left-hand side.

But the basic research with high visibility, much of it is in the right-hand upper block, is in the area of nuclear and particle physics—in fact, if I may see the next viewgraph?

Here is a picture of our accelerator at the Los Alamos Meson Physics Facility. That installation is really the flagship of this country's nuclear physics program, particularly in the area of mediuim energy physics.

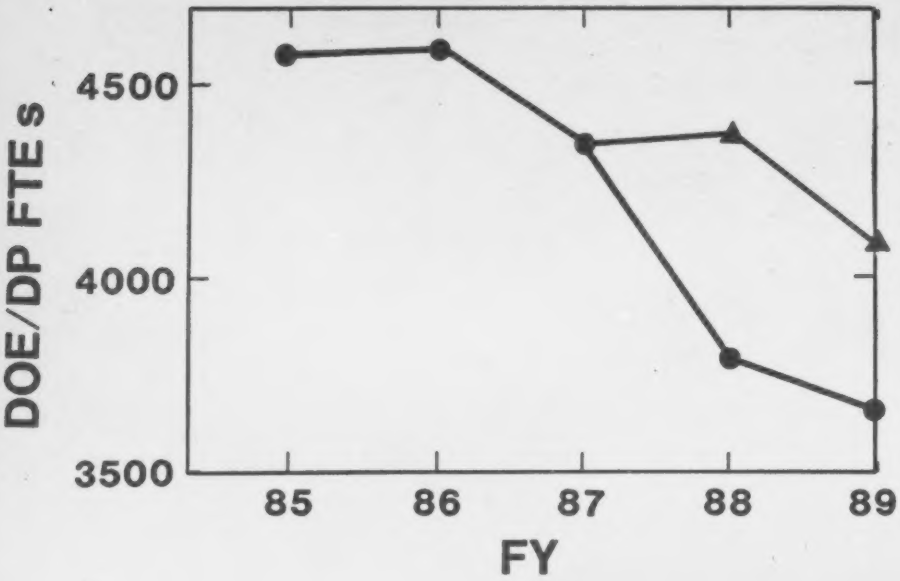

LOS ALAMOS MESON PHYSICS FACILITY

It has allowed us to stay on the forefront, to be able to attract people, and do research that is of extremely high caliber.

In addition, it has allowed us then to spin off ideas and people into the defense arena. For instance, the neutral particle beam really had its beginnings at this laboratory facility and particularly with people whom we brought to the laboratory with the medium energy physics program.

If I may go back to the programs viewgraph again?

DOE/DEFENSE PROGRAMS



PRESIDENT'S BUDGET

Los Alamos

Essentially, all of the other areas have similar examples of interesting research. For instance, in basic energy sciences, we work with DOE funding in one of the hottest areas of science and technology today; that is, the so-called high temperature superconductors.

We have worked in the superconductivity arena for a number of years and have discovered some interesting model types of superconductivity. Now we are also involved in the high temperature superconductors which have the potential of enormous technological breakthroughs, not only for defense but for private industry.

Senator JOHNSTON. That has not been overstated in the media.

Dr. HECKER. There is a lot of hype associated with that. It is a peculiar change in science when, instead of publishing in physics letters, one publishes in the New York Times first. There is a lot of hype, but the technical potential of the high temperature superconductors cannot be overstated.

Senator MCCLURE. That's what attracts the good scientists. [Laughter.]

Dr. HECKER. Not only from that standpoint, but in terms of significant technological impact on other than the laboratory. The impact will be immense.

I will just quickly run through the work in magnetic fusion, health and environmental research, nuclear energy, and still a number of alternative energy topics. Also, in the reimbursable area, we work for a number of other government agencies, including the ones that I have listed there.

CENTRAL AMERICA ENERGY AND MINERAL ASSESSMENT

I will just elaborate a bit on the Central American project. It is a project that we are working on with the AID organization. It is a project where we are working with a number of Central American countries to try to help them assess their energy and mineral resources and how to benefit economically——

Senator JOHNSTON. We had better speed this along, or I am afraid we are going to run out of time before we have time to ask questions.

Dr. HECKER. Let me just end there by saying that those programs are indeed also in the nonmilitary arena.

Let me go on from there and take a specific look at the budgetary impact. I think the points have been made, and they were made well by Roger, that in terms of stability and capability of the laboratory, we would like to see those preserved.

We think it is extremely important for the health of the laboratory to have a strong mission, and that strong mission is the one that we have already mentioned. In addition then, we have the capability of helping in a number of other areas.

John, if I may have the next viewgraph?

[Change of viewgraph.]

Senator MCCLURE. Mr. Chairman, I wonder if I might interrupt for just a moment because I do have an appointment in my office at 4. It is one you would keep, too, if you had it with Secretary Herrington. [Laughter.]

I apologize for having to leave, but Senator Domenici had one question he wanted to have asked on the record today. If you would see that that was done, I would appreciate that at the appropriate place.

And second, just because there is a switch going on which I think the committee ought to note and you, Mr. Chairman, should note, is that we are trading from Washington to Idaho and from Idaho to Washington; and the man who will be sitting for Mr. Ofte has been sitting as the Director of the Idaho lab.

And that is Troy Wade, who is here today—Troy and Mr. Ofte will be switching positions. And we will gain Mr. Ofte's experience and expertise at the Idaho lab, and Washington will gain the expertise and background of Troy Wade, which we think is a good winner for both of them and for all of us.

So, I did want to note Troy Wade's presence here today.

Mr. Ofte's next appearance before this committee may well be as the manager of the Idaho operations office.

BUDGET SUMMARY

Dr. **Hecker.** Let me continue and try to close on the budgetary picture. If you look at the defense programs portion of the laboratory, which, as I have just pointed out, is better than one-half of the laboratory's total activities, I show the FTE chart as a function of years.

As you can see, from 1986 to 1987 and for the current fiscal year, we have lost about 250 FTE's from the defense programs effort. On the basis of the President's budget projection, which is the top line on this chart, you can see that it holds steady in 1988 and then decreases in 1989.

If we work the current exercise, which we have worked with the DOE and that is of level dollars, and make certain assumptions that we have worked with DOE defense programs about our share of what that particular cut would be, then you get the lower line that is indicated there.

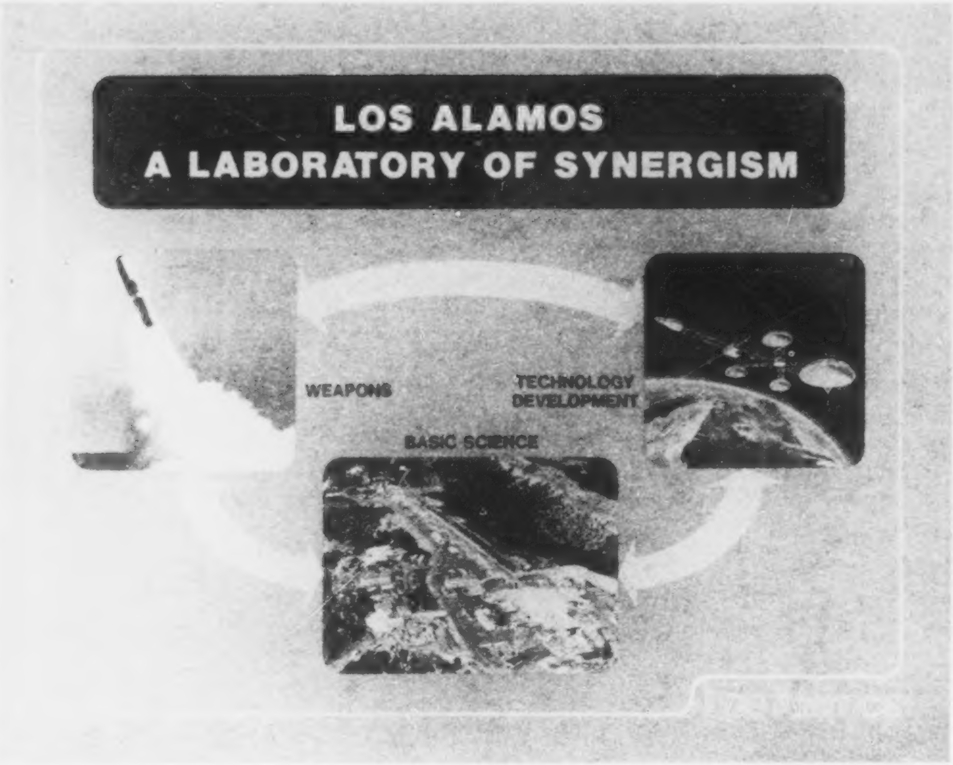
That would result on the order of another 550 reduction FTE's from this program, which makes up the strong primary mission of the laboratory.

Rather than going into specific aspects of the programmatic impact, let me just leave the word that, as Roger has pointed out, I think those effects indeed can be devastating on the laboratory's overall capability.

The other points that I would like to mention are that certainly we ask for your support in the area of construction. It is always very tempting to try to take the money from line item construction. However, I would like to make the point that construction is indeed the future from the standpoint of being able to have the proper facilities for research and development.

Also, in today's complex with the aging facilities, a certain amount of construction is needed to renovate and replace aging facilities.

So, let me stop by showing the last viewgraph.



LOS ALAMOS
A LABORATORY OF SYNERGISM

WEAPONS
TECHNOLOGY DEVELOPMENT
BASIC SCIENCE

The laboratory is indeed a laboratory of synergism where we do basic science, we do technology development, and we do weapons. We do it principally in the defense arena and primarily for nuclear weapons technology, but as I have shown you, we also do it well in a number of other areas.

Thank you.

Senator JOHNSTON. Thank you very much, Dr. Hecker.

SANDIA NATIONAL LABORATORIES

STATEMENT OF IRWIN WELBER, PRESIDENT, SANDIA NATIONAL LABORATORIES

Senator JOHNSTON. Mr. Welber, I hope we are not going to have to short change you, but we are rapidly running out of time.

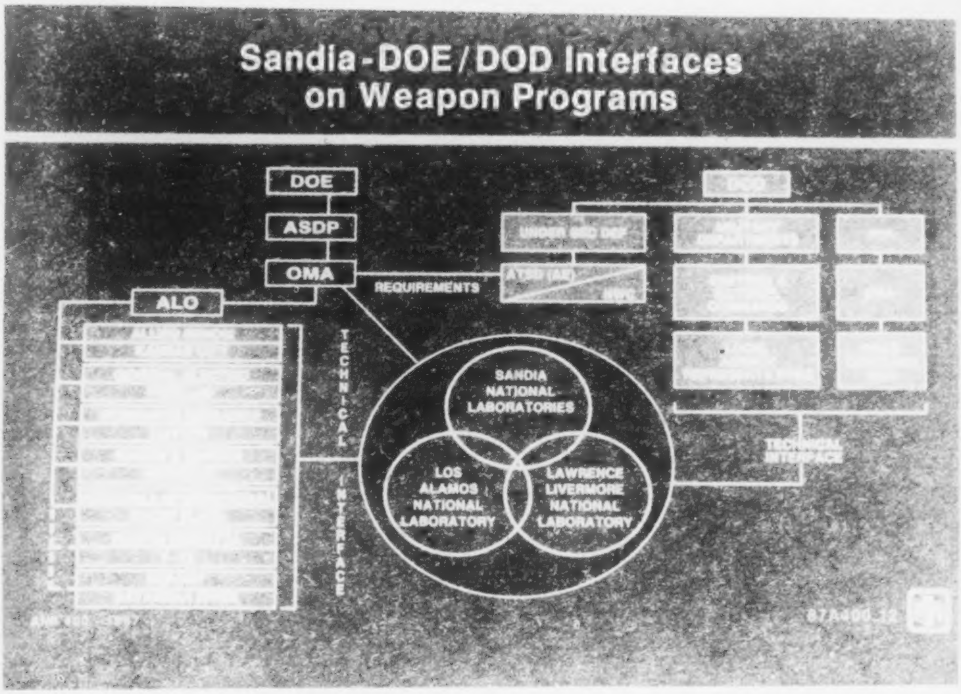
Mr. WELBER. How much time would you like me to take? I can take as much or as little as you like.

Senator JOHNSTON. I would like to get the essential part, but if you could do it in 5 or 6 minutes?

Mr. WELBER. All right.

I would like to stand up there.

Can you hear me all right if I work from here? I think I can work much faster.



Sandia-DOE/DOD Interfaces
on Weapon Programs

DOE

ASDP

OMA

ALO

REQUIREMENTS

TECHNICAL INTERFACE

SANDIA NATIONAL LABORATORIES

LOS ALAMOS NATIONAL LABORATORY

LAWRENCE LIVERMORE NATIONAL LABORATORY

DOD

UNDER SEC DEF

ATSD (AE)

TECHNICAL INTERFACE

87A400-12

I would like to indicate, first of all, that Sandia is the national laboratory which turns the nuclear device into a weapon. We do the engineering.

As Siegfried Hecker said, the national laboratories are unique, perhaps unique in all of industry, in that they take from the research the idea, to the product, to the manufacturer, right to the user to retirement.

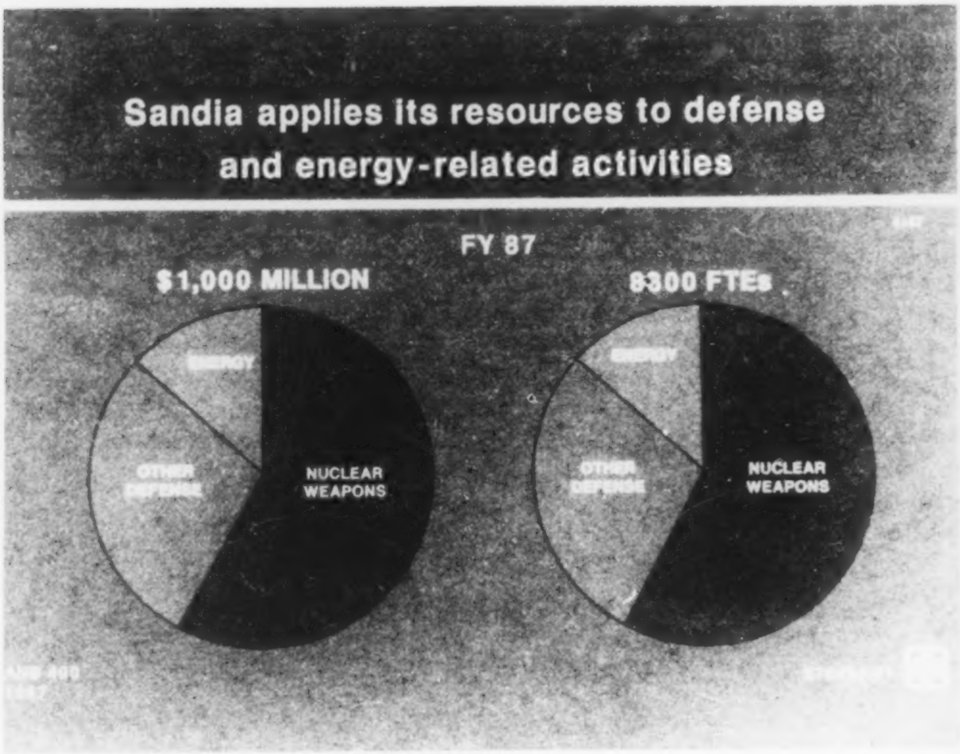
There was another organization that I spent 35 years with that did that. That was Bell Laboratories, part of the AT&T system, which did exactly that.

And the analogy, I think, is rather significant. Forget the words here, but look at the colors. This is the R&D organization of the three labs we have been talking about.

These are the users: DOD, the military services, who generate the requirements. This is the DOE, who manages the complex. And this is the manufacturing.

So, herein we have a complete vertically integrated structure with Congress providing the oversight. This is analogous to the former Bell System. We hope the same thing does not happen here. [Laughter.]

We hope wisdom will prevail here.

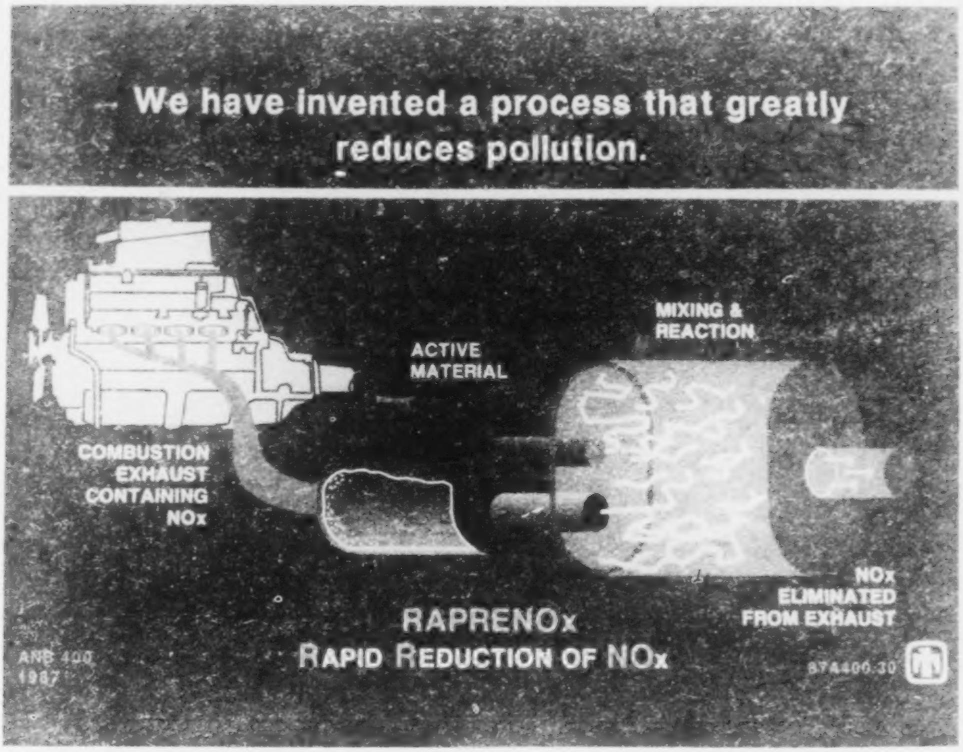


Sandia applies its resources to defense and energy-related activities

I would just like to say that this is the work we do at Sandia. It is roughly 60-percent nuclear weapons, about 30-percent defense, and 20-percent energy. The energy, as a segment of what we do, has been going down.

I would like to say a few words about that. I am going to skip a lot of that.

I know you expressed interest in technology transfer and what we can do from the products of what we develop, our research in the nuclear weapons field—how can we help U.S. industry?



– We have invented a process that greatly reduces pollution.

ACTIVE MATERIAL
MIXING & REACTION
COMBUSTION EXHAUST CONTAINING NOx
NOx ELIMINATED FROM EXHAUST
RAPRENOx
RAPID REDUCTION OF NOx
ANB 400
1987
874400.30

I would like to give you one example, which I think is a good one. [Deleted.] That is, we reflected laser beams into the mixing gases and, from the reflectivity and the absorption and the transmissivity of the laser beams, we learned an awful lot on a nonintrusive way of how those gases were mixing.

[Deleted.]

Mr. Welber. The people working on that said these techniques could also be applied to the understanding of the internal combustion engine.

So, from those techniques, we have created a facility at Sandia/Livermore called a combustion research facility. We have been learning a tremendous amount about the internal workings of the internal combustion engine.

We work with Ford, General Motors, Chrysler, unfortunately Datsun, Toyota——

[Laughter.]

Mr. Welber [continuing]. And Mercedes. It is open to the world, but that technology is benefiting U.S. industry.

Senator Johnston. Why should it be open to the world?

Mr. Welber. Well, we haven't found a way to close it. We do not encourage it, but when the Japanese request a visit, we show them what we can do. We also learn from them.

Senator Johnston. Is there a trade deficit in that respect?

TECHNOLOGY TRANSFER

Mr. WELBER. I couldn't tell you what the size is, but we can talk about problems, about transfer of technology from the national laboratories to U.S. industry.

One of the areas is: How do we make a transfer of technology to U.S. industry and keep it that way and not share it with the rest of the world? That is an issue I think we have to face as we get into this deeper and deeper.

But from that facility—the combustion research facility—in which we are learning about the internal combustion engine, some of our engineers and scientists also invented ways to use a very common chemical—cyanuric acid—which is a chemical used in swimming pools to fix the chlorine in swimming pools. It is cheap and available.

With the proper use of that chemical, they have been able to reduce the noxious gases from a diesel engine by a factor of 97 percent—almost completely eliminating the noxious gases from a diesel engine.

That in itself may revolutionize the diesel industry. You have to understand that it has the potential to put that in industry.

If you use the cyanuric acid plus limestone injection which reduces sox emissions—you can eliminate the cause of acid rain from smokestacks.

Senator JOHNSTON. I must say I am very impressed with that. I think you ought to find a way to limit it to the United States.

Mr. WELBER. We are working with the Cummings engine. You have to select a supplier—a manufacturer—who is willing to invest the money to find out the fine print about this technology, and that company has to invest money. They have to really invest resources to make sure it really has this potential.

I was just trying to give you an example of how this technology, which started in the nuclear sciences, can benefit industry.

And with that, I will conclude my statement.

Senator JOHNSTON. Thank you very much, Mr. Welber.

Let me ask a few questions on some related matters here since I have got all this concentrated brain power here.

STRATEGIC DEFENSE INITIATIVE

First of all, on SDI, the decided weight of the scientific opinion which I have gotten is that we will not be ready to make a choice of technologies in SDI until some time in the 1990's, and they usually use, I think, the 1992–94 timeframe.

Would I get an argument on that conclusion?

Dr. HECKER. I would say from the standpoint of our research program, they are aimed at that timeframe to try to make the decision in the early 1990's as to which of the technologies, for instance, that we are working on at Los Alamos, may be ready.

Mr. WELBER. I don't disagree with that.

Senator JOHNSTON. And do you agree with that, Dr. Batzel?

Dr. BATZEL. We can speak to the technologies on which we are working as a laboratory and, again, the timeframe we are talking about is well into the 1990's.

I have a little trouble knowing what is really technically feasible and viable with respect to earlier forecasts.

Senator JOHNSTON. You also do work with the architecture?

Dr. BATZEL. Yes.

Senator JOHNSTON. And the overall management of the architecture?

Dr. BATZEL. Yes.

Senator JOHNSTON. So, you know a little bit about everything? I mean you know a lot about everything. [Laughter.]

I was thinking of that old song, "I know a little bit about a lot of things." [Laughter.]

But your knowledge would reach to all the areas?

Dr. BATZEL. It extends a little bit into those areas. One of the difficulties we have at this stage of the game is that we are not brought into those architecture studies in as effective a way as we might.

I think George Miller today spent some time over in the SDI office to make sure we are coupled into that; so, we can make sure our input is there, and we understand what their input is and what the basis is for their judgments.

Senator JOHNSTON. All right, and a corrollary of that, of course, is that kinetic kill—the vehicle—a decision should not be made this year or next year to go to a development of a kinetic kill vehicle system.

Do I get any disagreement on that?

You know, I don't want to embarrass the lab heads, but one of your important roles is to be able to give advice to the Congress, and I know what kind of stress that puts you under because I know specifically what has happened because of questions I have asked.

And I apologize for that, but that is the role of the national labs. That is why you are so valuable to us.

Dr. HECKER. Let me try to tackle it from at least a very limited standpoint. From our way of looking at it, and a question to be deployed is a question that is much larger than one that a laboratory can answer.

There are many, many factors that go into that consideration.

From a technological standpoint, the point that we have been trying to make is that if one is thinking about deploying the kinetic energy kill concept now or soon, let's say, then indeed one has to make sure that one continues to work on the next generation of enabling technologies which would make a phased deployment really a feasible approach.

And so, we would say that we would not want to see early deployment without work and without looking at really a phased system, particularly the research that still needs to be done on enabling technologies such as free electron lasers, neutral particle beam, and so forth, because we feel that they will be necessary.

FUNDING TRENDS

Senator JOHNSTON. I would suggest two things from that.

First, that an early deployment of KKV cannibalizes free electrons and neutral particle beams and all the other beam weapon technologies; and haven't you already seen that in your budget?

First of all, doesn't your budget reflect this? And aren't your beam technologies being reduced this year?

Dr. HECKER. From the standpoint of the Los Alamos budget for 1987, it didn't grow to the extent that we had anticipated; but I would say it is funded at a reasonable level.

The neutral particle beam program is certainly well funded. We would like to see more funding for the free electron laser program, but at least it is funded at a reasonable level.

Our real concern is for what will happen in fiscal year 1988.

Senator JOHNSTON. With the projections right now, we know what those are. You are up on KKV's and the beam program is down in general; isn't that correct?

Dr. BATZEL. I haven't seen any fiscal year 1988 breakout, but I know in fiscal year 1987, again, we are in the same situation. We didn't grow in the free electron laser, I guess, as much as we had hoped.

Senator JOHNSTON. As much as the projection?

Dr. BATZEL. The initial projection; yes.

Senator JOHNSTON. In other words, they have changed the focus of the program. The focus of the program has changed by increasing KKV and down in the beam area; is that fair?

Dr. BATZEL. Certainly those funds went some place besides the two laboratories; for example, in free electron laser work and others.

Dr. HECKER. May I take just one more crack at that?

I have not personally seen the breakout for fiscal year 1988 for the directed energy funding out of SDIO, but I must say that if either the neutral particle beam or free electron laser is significantly affected, it certainly goes back to what we were trying to say earlier, that it makes it extremely difficult for a laboratory like ours to get together their resources, mount the effort, and do a research program that takes a number of years, if the budget is going to be jerked around on an annual basis.

But I cannot speak specifically to 1988, because I have not seen a specific breakout.

PHASED DEPLOYMENT OF SDI

Senator JOHNSTON. Next, the phased deployment suggests that there is a natural progression from KKV's to beam weapons. I would suggest that there is no such thing, that there is no such logic to that progression.

To the contrary, there is first of all a dissonance to the two, because the one cannibalizes the other budgetarily. Second, there is no commonality between the two systems—you can take out the KKV rockets and insert a beam weapon in the orbiting satellites. But maybe there is a commonality in battle management, but not in the systems themselves.

Now, would you argue that?

Dr. HECKER. I would argue with that from the standpoint that I can certainly see some of the technologies being used in a phase manner.

And that is that, if you initially put the KKV up, eventually you will need significant capabilities for discrimination. For instance, that is when you can phase in the enabling technologies of a second phase, such as the neutral particle beam or what have you.

So, in that sense, I think the phasing would work.

Senator JOHNSTON. All right. Would you go through that again?

Dr. HECKER. Initially, if you put up KKV——

Senator JOHNSTON. KKV has no projected or present ability to discriminate?

Dr. HECKER. That is correct. In order for that system to stay viable for any length of time, you will need significant discrimination capability. That can only come through the next phase of technology.

That phase would be, say, neutral particle beam or perhaps other technologies.

So, in that sense, I can see that being a technological phasing.

Senator JOHNSTON. Technological phasing in the sense that you would be putting up a system knowing it was deficient to begin with, which would drive the need, maybe, for the second phase. That is the only logic I can see in it. Is that wrong?

Dr. HECKER. I think the argument that one would make against that is that, initially, the discrimination is not as important as it will be in a 5- to 10-year timeframe, at which time the adversary has had a chance to respond to your initial deployment.

So, I think that is the argument that would be made; that is, the significant discrimination is not as deadly in the first stage as it would be, let's say, 5 years from then.

Senator JOHNSTON. It is not really a stepping stone. I mean, a phase suggests a stepping stone that you do step one in order that you can build on that for phase 2.

There is no building here. There is simply one set of technologies that you are going to replace with another whole set of technologies, leaving out, of course, your battle management and the associated computer capabilities which might be common to both, but again which is not a phase at all.

Dr. HECKER. I think that in terms of phases, you and I are talking about two different types.

Senator JOHNSTON. You are talking about just step one and step two, without being a logical progression?

Dr. BATZEL. Clearly, some of the tools like the boost surveillance tracking system would be important in future systems. Satellites that can discriminate those capabilities would be useful.

Another view would be that it is important to do experiments which give you the real basis for judgment

KINETIC KILL VEHICLES

Senator Johnston. I certainly won't argue with that since I have been saying that all along.

Let me ask you another question. I don't want this to be solely SDI, but we don't often get this type of expertise together at the same time.

We have also developed—from those experts with whom I have talked—that kinetic kill vehicles can be defeated by the fast-burn booster, that the fast-burn booster could be developed by the Soviets sooner if we both said we are going KKV deployment and the Soviets said they are going fast-burn booster—they could get there sooner.

Point No. 1. They can do so at a fraction of the cost. Now, is that fair? Do you disagree? Or is that out of the field?

Dr. Hecker. From my knowledge of that, the most I would be willing to say is that certainly that is very controversial and not wholly agreed upon.

I think there are many who will claim the opposite, that you cannot defeat the KKV with the fast-burn boosters. So, it is an area of substantial controversy and that I personally would not feel qualified to answer.

Mr. Welber. In our system studies, Senator, the question is how fast are we considering coming to fast burn?

Senator Johnston. Fast enough? The first 70 seconds is under the atmosphere where it is invisible anyway, isn't it?

Mr. Welber. That is right.

Senator Johnston. All right.

Mr. Welber. If you really want to get down to some very fast burn boosters, that is a technological achievement which is of immense expense. It is a very large job to get fast burn of 30 seconds or thereabouts.

Senator Johnston. Well, I mean a practical—let's say 100 seconds, which is certainly achievable now. We have what?

Mr. Welber. Certainly, 150 is what we are capable of today. It depends on how fast you are talking about as to how big a job it is.

Senator Johnston. Yes. Well, shouldn't 100 seconds be practically enough? With the absentee rate, the 100 seconds would be immense, wouldn't it, on anything other than just a massive, massive deployment—an unaffordable deployment?

Mr. Welber. I have read estimates that it would be a major undertaking to design the whole new booster systems to get in that vicinity. It is not a trivial task at all.

Senator Johnston. Not trivial, but——

Mr. Welber. Is it more complicated than the KKV? Is it going to take more fuel resources to do? I think that is controversial. I would hesitate to state an opinion.

Senator Johnston. Dr. Batzel?

Dr. Batzel. I have the same kind of problem that they have, but if I had my choice, I would rather do the fast-burn booster than the KKV.

Senator JOHNSTON. I won't go into the detail we have had on some other hearings on that, but I think that is fair; and I think that is also very diplomatic.

Dr. HECKER. I think that part of the controversy is associated also with the vulnerability in the bus stage. So, it really gets to be a significant controversy.

NUCLEAR WASTE DISPOSAL PROGRAM

Senator JOHNSTON. Now, on the question of nuclear waste, how could we use the labs on nuclear waste?

And let me tell you what we found on our trip to Sweden and France. For example, the Swedes built a facility that is for medium- and low-level waste, but nevertheless it involves about 5 kilometers of shafts—huge shafts—like the metrorail systems here in Washington, dug down into the solid granite with storage pits and all of the rest of it.

They built that for, as I recall, $100 million, and 30 meters under the sea.

The French are going to characterize, as they call it, five sites. At one of those sites, they will actually sink a deep shaft and build an underground laboratory there; and that will be the full characterization.

And they will also characterize four other sites. The four other sites that they will characterize will be $10 million each. That will involve some core drilling.

The underground lab, I think, they are building for about $70 million. Now, the figures that we have been given to characterize three sites in this country will cost $1 to $1.5 billion each. And we asked the Swedes and the French what is responsible for this, and they said: "We don't know what in God's name they are spending that money for over there."

The French responded: "We have an operating rule, which is anything that we can do for a franc will cost the Americans a dollar." That is a 6-to-1 ratio.

Now, we need some help from somewhere, and I don't know where we are going to get it; but we have our labs here now. So, can you give us some suggestions on how we can reconcile that program?

I mean, it is not that we are going to be safer than these others. It is not that it is a better program. It is certainly not that ours are going to be more widely supported by the public. [Laughter.]

Dr. BATZEL. I think you have touched on the fundamental issue right there. It is the question of acceptance by the public. And the question is: What do you have to do to convince enough of the people that you know what you are doing so they will let you store this waste under the ground?

Mr. OFTE. Mr. Chairman, there is another comparison that might be useful, and that is with the Waste Isolation Pilot Plant near Carlsbad, N. Mex. That is one that is for defense transuranic waste only. Because it is strictly for defense waste activities, it was specifically exempted by the Congress from NRC regulation.

A great deal of the cost of the commercial repository is associated with the kind of data base and the conditions under which that is established that that program has to accommodate to meet NRC criteria.

Senator JOHNSTON. But $1 billion?

Mr. WELBER. No; we are responsible for the waste site, and I want to go back and find out just how much we spent. But I dare say, it is comparable to the kind of numbers you are talking about here.

Mr. OFTE. DeWitt is a repository, and it was $700 million, not just for characterizing and shaft; but this is for the complete facility, with surface-handling facilities and the like.

Senator JOHNSTON. We are not talking about building this thing for $1 billion.

Mr. OFTE. No, sir.

Senator JOHNSTON. It is going to be multiple billions.

Mr. OFTE. It is $30 billion for the repository overall.

Senator JOHNSTON. I mean, I think somewhere we have lost the discipline of OMB when we say this is nuclear. So, you are not going to have free enterprise doing it with a profit motive, and you are not going to have government do it with OMB and budgetary deficit considerations. Just go out and spend the money, boys. I think the phrase, "Spending like a drunken sailor" is entirely apt from what I know about it; and let me say that Ben Rusche is not only a great friend of mine, but I am a great booster of his.

He is a very, very good man, but somehow he doesn't have the help or the backup or the depth or whatever over there at DOE, and I am going to talk to Ben Rusche. But we need some help. Are the labs the appropriate place to look for it?

I might add that GAO has had the team looking at the nuclear waste effort—I think nine people, full time—and we have yet to get the first piece of paper from GAO as to what we are doing right or wrong or where this $1 billion came from. It is bizarre.

Dr. BATZEL. I would be quite willing to go back and ask my people who are working in that area if they have some recommendations.

Mr. WELBER. I think it would be very important for us to know just what the Swedes and the French did with the money they did it for and the rules and regulations they operated under to accomplish that.

Senator JOHNSTON. That is one of the things we need; we need an evaluation of those kinds of things.

Doctor, you were talking about sort of the systems management approach which the labs have, where they can take an idea from the start to the finish and look at producibility, which means you look at the dollars it costs to produce it. I just don't think we have that discipline in our nuclear waste program.

And the national labs could contribute significantly in this area; and nuclear enrichment, as well. We will have to deal with that as well.

But nuclear waste is going to be here for a long time, and it is a huge program in terms of dollars; and we badly need some management help, I think.

Dr. BATZEL. It is clearly a very important issue to settle in a positive way.

Dr. HECKER. I think, from my standpoint also, what I have seen is that all three of our laboratories have worked on the technologies associated with nuclear waste; and those are certainly appropriate areas for us to work in.

Plus, perhaps we could take a more global view, as you suggest, which would probably also be helpful. But I am afraid that the major problem may not be a technical problem, but indeed associated with what Don Ofte mentioned, and that is the regulatory climate.

There is quite a good comparison with, let's say, what the French are able to do in nuclear waste versus the United States compared to what the French are able to do in nuclear power compared with what the United States is able to do.

And you will also see staggering differences in dollar figures, of course, in being able to complete the nuclear powerplant.

Senator JOHNSTON. There is no doubt about that.

Dr. HECKER. And I think it reflects the same basic problem—that there is a very different regulatory climate in the two countries, and that comes all the way back to the nuclear waste problem as well.

Senator JOHNSTON. There is no doubt about that; and by the way, you just saw the plant in Oskersham that was constructed in 4½ years, and that shows the comparison.

One of the requirements that we wrote into the law was to characterize three sites. And I would like to have confirmation of the degree of certainty with which we could characterize one—I mean, pick one.

Now, Livermore must know enough about the geology at Nevada Test Site to tell us what degree of confidence we might have if, for example, we went for that site.

Dr. BATZEL. We can certainly give you a view. I can't give you that view today.

Senator JOHNSTON. I wish that you gentlemen would give us information telling us what role the labs might be able to play in nuclear waste. In other words, an evaluation of allotted regulatory requirements, if nothing else, would be important, to tell us where the problems are, how we might change our laws if necessary, how we might have a better management system that puts safety first. But also an analysis of the costs, because, as I say, we are looking at big bucks.

Dr. HECKER. That is a big assignment. We would be happy to do it for the record.

Senator JOHNSTON. Yes, that is what I am talking about; not now.

Dr. HECKER. For the record.

Senator JOHNSTON. Yes.

[The information follows:]

Letter From Irwin Welber, President, Sandia National Laboratories

May 20, 1987

The Honorable J. Bennett Johnston
Chairman, Senate Appropriations Committee
136 Senate Hart Office Building
Washington, DC 20510-1801

Dear Senator Johnston:

I would like to thank you for the opportunity to provide testimony at your committee hearing held on April 22.

During that hearing you discussed the high cost of our commercial nuclear waste program and asked what role the National Laboratories might play to reduce that cost. We at Sandia are already involved in the civilian waste program contributing in the area of spent fuel transportation and in the characterization of the Yucca Mountain site and preliminary design of the repository. We are also contributing to the defense waste program, specifically defense waste transportation and the Waste Isolation Pilot Plant in Carlsbad, New Mexico. This is about a 320 person effort equally divided between the civilian and defense waste efforts. We would welcome the opportunity to make additional technical contributions if asked to do so.

Based on this experience, I do not believe the high costs of our waste management program stem from the technical difficulty of the task. Instead, I believe the high costs are more deeply rooted in the values of our society and in our political system, both of which we all cherish. Our citizens don't want somebody else's waste deposited in their state. For instance, look at what happened to the New York garbage barge. Our political system tries very hard to accommodate the views of all of our citizens. I have attached a paper which addresses some of our views on this subject. I hope you will find it informative.

If you have any other questions, please don't hesitate to contact us, and thank you again.

Sincerely,

Irwin Welber

Cost of US Repository Program

One might be tempted to explain away the difference in cost of the US and Swedish repository programs based on the major differences in the sizes of the repositories required by each. Current projections for nuclear power in the US indicate a total of about 120 reactors or about 110 gigawatts electric-generating capacity. Sweden, on the other hand, has only 12 reactors and 9 gigawatts electric-generating capacity. The required repository will be concomitantly smaller and less expensive.

In reality though, the answer is not that simple. The US is not benefiting from the economy of scale as it should. There is a major difference in what the two societies demand when confronting technical issues. In particular, one consequence of US society is a more adversarial approach to solution of such problems. As a result, the US's high-level waste disposal program has evolved to be extremely contentious and those playing roles have become firmly entrenched in their own positions. The public seems to have developed a position that there should be no health risk associated with waste disposal. Obviously, this is an impossible requirement. Therefore, this unreasonable expectation poses political and institutional risks for those involved in implementing the US program. The cost to attempt to eliminate all vestiges of risk for all parties involved is staggering. Some specific examples of this enormous US effort follow.

First is the requirement established by the Congress that three sites must be completely characterized before the site for the first repository is chosen. No other nation is taking such a conservative approach. There is inherently little common effort among the three sites; therefore, site characterization costs and the attendant cost of design, analysis, and prelicensing activities are about three times what they would be for only one site.

Second, the number of oversight personnel is staggering. In addition to the several responsible congressional committees, oversight in various forms is undertaken by the utilities/nuclear industry, utility regulators, States, Indian Tribes and local governments. Perhaps some specific figures would illustrate the impact of such oversight on costs. Here I draw comparisons between the DOE's high-level waste repository program and the DOE's WIPP project. The DOE funds the State of New Mexico to provide oversight to the WIPP project. This oversight has been very effective and has been a significant contributor to the Project's success, both technically and institutionally. The cost for this oversight has been less than one million dollars per year. In contrast, affected states in the high-level waste repository program perceive that they must have zero trust in the DOE effort and, therefore, their oversight role must be much greater. The State of Nevada, for example, has requested budgets more than ten times greater than that of New Mexico's for WIPP.

To continue this example, the State of New Mexico Environmental Evaluation Group, the oversight group for WIPP, consists of about ten people. The high-level waste repository program is faced not only with expanded oversight by affected states to include several tens of people, but by an NRC force, including contractors, of several hundred as well. All this for only the site characterization phase. Responding to such an overwhelming body of oversight personnel, particularly in a public forum setting, requires a substantial effort.

The real tragedy of all this is that the nuclear waste repository is not a particularly high-risk facility either in an absolute sense or relative to risks we routinely accept in an industrial society. This point is explicitly stated in 40CFR191, the EPA regulation which serves as the basis for NRC licensing of the repository. I have extracted a part of Section 191.13:

> "The Agency assessed the performance of a number of model geologic repositories similar to those systems now being considered by DOE. . . . For the various repository types, these assessments indicate that disposal of the wastes from 100,000 metric tons of reactor fuel [about what would be discharged from all US reactors under present conditions] would cause a population risk ranging from no more than about ten to a little more than one hundred premature deaths over the entire 10,000-year period, . . .
>
> "The Agency also evaluated the health risks that future generations would be exposed to from the amount of uranium ore needed to produce 100,000 metric tons of reactor fuel, if this ore had not been mined to begin with. Population risks ranging between 10 and 100,000 premature cancer deaths over 10,000 years where associated with this much unmined uranium ore, depending upon the analytical assumptions made. . . ."

In other words, the EPA's analyses indicated that the long-term risk of the repository is no greater, and probably less, than if the ore body that supplied the reactor fuel had not been mined in the first place. Of course, this comparison does not include risks involved with the remainder of the fuel cycle, which should properly be compared with extraction and use of fossil fuels.

NUCLEAR TEST BAN TREATY

Senator JOHNSTON. Now, I also would like to know what we might do if this test ban treaty comes in, what problems that presents for you. I know retention of your best scientists is a real problem, but you have seen all the news about the test ban treaty as one of the amendments to this treaty.

I think the President has said he may veto that, but you might be preparing a response to us on what problems that presents and what changes might be helpful.

Dr. BATZEL. I would like to provide that for the record.

[The information follows:]

Lawrence Livermore National Laboratory

PREPARATIONS FOR A CESSATION OF TESTING

Under strict test limitations, my Laboratory would have to do its best to ensure the reliability of nuclear weapons. Accordingly, we have long been concerned with how we could carry out our responsibilities under treaties like a Comprehensive Test Ban (CTB). Future stockpile problems will inevitably occur. At the very least, our responsibilities under a CTB will include attempting to ensure the reliability of the existing stockpile, assessing changes in weapons caused by stockpile aging, and assessing corrections of potential problems. It also appears likely that under such a ban, many of our responsibilities could not adequately be met.

It is also inevitable that requirements for new weapons will occur. The new weapons may require new warhead designs. Changes in weapons design are dictated by safety and security considerations, use of new materials, new configurations, or new military requirements. Not all such changes require certification by full-scale nuclear tests, but all rely on data obtained in nuclear tests and, most critically, on the judgment and insight that scientists and engineers acquire on the basis of such data. Under a CTB, as well as lower yield threshold test bans, experimental data could not longer be obtained from testing, the pool of experienced specialists would decline, and the skills of those that remain would diminish.

There is no satisfactory way to solve these problems. They may be alleviated to some extent by such measures as: (1) improving our understanding of present nuclear designs including such basics as equations of state, opacities, radiation implosion, and instabilities, by current nuclear tests and other means; (2) placing increased emphasis on the use of supercomputers and numerical models and on the vigorous development of advanced computers; (3) taking even more deliberate steps to maintain a capability to remanufacture old weapon designs; (4) acquiring experimental facilities to augment our current nonnuclear testing capability; and (5) applying our nonnuclear experimental capabilities to activities which might partially sustain weapons expertise if there were a CTB. All of these approaches are being pursued. A sixth approach would be to develop warhead designs that would be much less likely to suffer degradation due to stockpile aging.

1. We regularly conduct weapons physics or fundamentals-of-reliability experiments at the Nevada Test Site (NTS) as part of nuclear tests scheduled for other purposes. Since 1981, *DELETED* LLNL tests per year have been dedicated to weapons physics research. The knowledge gained from these tests has already permitted us to develop more conservative and reliable designs. But the committee should also understand that the total number of U.S. tests is already too low. Modernization and advanced development tests already do double duty as training experiments to develop designer judgment and knowledge.

2. The Laboratory is constantly acquiring the most advanced supercomputers available. The Livermore Computer Center currently has two CDC 7600 computers, four Cray-1 computers, a Cray-XMP 4/8 computer, and a Cray XMP 4/16 computer. Much research is devoted to developing improved computational methods to make optimum use of advanced computer architectures and to improve the accuracy of the physics models in our weapons design codes. We should continue to acquire state-of-the-art computational facilities and to develop our computer modeling capabilities. Under increased test limitations, our requirements for computational capability will be larger than present since it would constitute our sole source of understanding. But I must emphasize that computational modeling is not a replacement for nuclear tests, but rather a tool that permits us to make more effective use of the information we derive from such tests. Today, and for the foreseeable future, we cannot model all of the complex

physical processes necessary to predict warhead performance with confidence and thus are frequently surprised in actual nuclear tests.

3. In order to maintain a capability to remanufacture weapons, we are placing major emphasis on 25-year objectives, materials compatability, and engineering durability. We also follow rigid documentation of production procedures and materials. We could implement further steps, such as continuing production of older weapons at a low rate. Such steps would involve substantial economic costs. However, even these steps cannot guarantee the adequacy of the production process; nuclear tests are the final experimental proof of the adequacy of our processes.

4. We are also pursuing weapons physics programs using our nonnuclear experimental facilities at Site 300 (our hydrodynamic testing area). The flash x-ray (FXR) facility at Site 300 and the Nova laser facility in Livermore represent recent augmentation of our nonnuclear testing capabilities.

   Repeated examination of these nonnuclear experimental facilities has not revealed any that could take the place of nuclear testing. Facilities that we can now envision for the future do not come close enough to simulating the conditions in a nuclear explosion. However, they can provide some relevant weapons physics data, help experimenters maintain some level of relevant skills, and provide a test bed for weapon designers to verify some theoretical aspects of weapons physics. For example, we are constructing the High Explosive Applications Facility (HEAF), which will provide a valuable test bed for high-explosive research.

   Under increased testing limitations, we would require major expensive extensions of facilities in order to significantly enhance our ability to make judgments on the basis of nonnuclear testing alone. A High-Gain Test Facility (HGTF), using a multimegajoule laser for research on inertial confinement fusion (ICF), would provide much more intense conditions than those available with the Nova facility, would produce conditions that would be more relevant to some aspects of nuclear weapons design and diagnostics, and would provide a source for some tests on military vulnerability, lethality, and exposure. Significantly enhanced capabilities would also be required for our implosion dynamics facilities (FXR) at Site 300 and the ability to carry out complex nonnuclear experiments at NTS. While we have not estimated the construction and operational costs of these facilities in detail, it is clear that they would require major increases in funds from those presently available to the WRD&T complex.

5. There are a number of nonnuclear weapon research programs that would help to maintain skills. For example, we currently have a program to develop advanced conventional munitions. Work on such munitions uses many of the same technologies (particularly hydrodynamics, material science, high-explosive chemistry, and high-speed diagnostics) that are involved in the development of the fission triggers for nuclear weapons. Unfortunately, in such research, we do not attain the temperature and pressure conditions characteristic of a fission explosive, and our expertise at those conditions would decline if we had to rely solely on such programs for maintenance of capability.

   We are also actively involved in inertial fusion research using our high energy optical lasers, such as the Nova facility.

   DELETED

   We are also using our nonnuclear facilities to help advance our research in nuclear directed energy weapons. For example, we are using our Nova laser facility to generate the conditions needed to pump x-ray lasers in the laboratory. The laboratory x-ray laser program is worthwhile pursuing in its own right, irrespective of the nuclear x-ray laser program, because of its potential physics and biomedical applications.

Under a CTB, it would be advisable to continue and to expand the above mentioned programs. But I must reemphasize, that while useful in maintaining some of our physics skills, such programs cannot address all of the weapon physics regimes that are characteristic of nuclear explosions. While such programs could slow the decline in capability, they cannot stop the decline.

6. The weapons we put in the stockpile were designed to be as conservative as possible within the constraints of meeting the military characteristics to hedge against the possibility of a CTB. Alleviating the impact of a restrictive test limitation by designing and manufacturing weapons even less likely to suffer degradation has been an often mentioned approach.

There would, of course, be costs in weight, size, use of special nuclear materials, and military effectiveness with such designs. This approach would be expensive and take decades to implement fully because of the configuration of the present stockpile and delivery systems. For example, larger primaries are seen by some as less marginal, but incorporating them in a weapon system would force expensive design changes in delivery systems. More importantly, as history has shown, we often cannot judge ahead of time which components will degrade. However, if it is judged desirable, we could, over a three-to-five year period, develop a set of generic, more robust warhead designs for a number of applications ranging from strategic warheads for an ICBM to tactical weapons. Such a development program would require extensive nuclear testing.

Final Comment

I want to emphasize that the steps I have outlined above are intended to slow the erosion of our nuclear design expertise. I do not believe that they will ultimately stop that decline. It must be recognized that we are an applied physics laboratory. In applied physics research, satisfaction with one's work comes from being able to test his theories against experiment. Without the capability to perform nuclear tests, we would be designing in a vacuum. The results would be paper designs and our people would know it. We have many striking examples of the disasters which can occur when people believe their calculations and paper designs.

I believe that most scientists and engineers need to know that the work they do is relevant to the Nation's needs. If the Country enters into a CTB, it will be telling these people that their work is unnecessary and undesirable. Currently, there is a national shortage of physicists. Scientists with the relevant training and background needed to design nuclear weapons will look for new opportunities elsewhere. There are many such opportunities and our people will have no problem landing jobs in other fields.

I do not suspect that the Soviets will be impacted to a similar degree. They have a closed society and would be in a much better position to retain weapon personnel in their programs. This could lead to a significant asymmetry in capability between the two countries.

LOS ALAMOS MESON PHYSICS FACILITY

Senator JOHNSTON. Now, Senator Domenici wanted to ask the following question: "In the recent markup of the Energy Subcommittee of the House Science Committee, it appears that the Los Angeles Meson Physics Facility will suffer a significant decrease in funding from the request and the President's budget for fiscal year 1988 of potentially $6 million out of $42.5 million.

"The purpose of these reductions is to add funding for the construction of two nuclear physics projects.

"Question one: What will be the impact of the House reduction on LAMPF?"

Dr. HECKER. That is for me to tackle since I am from Los Alamos. In fact, the Meson facility is the one that I showed that I consider the flagship of nuclear physics in the country and an extremely important aspect of basic research.

Senator JOHNSTON. Let me interrupt, Doctor, to give you the second question, too, because I think they are related. You can answer them both together.

"Question two: What is the significance of LAMPF to Los Alamos and to the nation?"

Dr. HECKER. Let me tackle the second one first.

I think I have already pointed out the significance of LAMPF to Los Alamos, and that is that it does provide a significant source of basic research for the laboratory.

It is extremely important both for the aspect of what I mentioned to be the importance of basic research and, second, it has had significant spinoffs to the defense world.

So, it is really vital to Los Alamos research, and therefore, for the overall institution.

From the standpoint of its importance to the country, it really is recognized as being the foremost facility for nuclear physics right now in the country.

And the specific impact, which is one, of course, that we are very much concerned about of the recent House action, is that those cuts are so significant that we could only make them up in two ways.

One is that there would be a reduction of people. The best that we can estimate now, as we have gone through these numbers since we first heard of this, is probably about 10 percent of the people working on the program at Los Alamos.

Second is there would have to be a significant reduction in the number of hours that the accelerator actually is on during the course of the year. The best we can estimate is that that would be around a 30-percent reduction in actual operating time.

Now, that means the impact would not only be severe on Los Alamos in all our research, but that accelerator is run by Los Alamos as a national user facility. It has many hundreds of users from the university community that use the accelerator to do their nuclear physics research.

So, when we cut down the number of hours available, we significantly impact the rest of the users—the communities—ability to do their experiments at Los Alamos.

We also feel that this was a very bad precedent to set, to take the operating money from a facility that is clearly at the forefront of research and use that to help build other facilities.

The facilities that are mentioned—others that are essentially next generation of accelerators that look at the problems in a somewhat different way than we currently do—the nuclear science community has gotten together and has assessed priorities for the new facilities.

And we have no problems at all with the priorities for the next two facilities and that they ought to be funded.

CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY

Senator JOHNSTON. Now, CEBAF has been cannibalized.

Dr. HECKER. That is correct. I think that that is a precedent that is very unhealthy for the scientific community.

So, the impact would be severe, and we certainly want to do everything we can to get your support to turn that around.

SUPERCONDUCTING SUPER COLLIDER

Senator JOHNSTON. All right. I know we all support the SSC, but what do you think this portends for other scientific and basic research programs if we commit ourselves to the SSC?

Dr. HECKER. You have heard my comment directly. This is a bad precedent to set. [Laughter.]

And especially when one looks at the price tags of the SSC compared to CEBAF and RHIC—the relativistic heavy ion collider—at Brookhaven. Those combined, perhaps, are a little close to the SSC.

So, you can just imagine that if you extrapolate that effect, it would be devastating on the scientific community.

Senator JOHNSTON. And you would say it would be better to keep those high-priority items we have rather than to strike off in some new geophonic explorer direction with provisions that were meant to be for you? [Laughter.]

Dr. HECKER. I can't subscribe to that view from a scientific standpoint. Naturally, the first priority would be to try to build the next generation and, hopefully, to be able to get additional funds to move science in that direction.

If science is going to be a zero sum, I think then that would certainly change many people's opinions on the SSC because——

Senator JOHNSTON. I am afraid science is going to be a zero sum. I don't foresee big increases without some serious taxes, and even with serious taxes.

And the facts of the matter are that we go through the budget resolution—even with $18 billion in taxes and cuts which have impacted on defense and on the civilian side—are unacceptable. They are unacceptable to defense and unacceptable to you from the impact it has on the basic programs of the national labs.

Even with $18 billion in taxes and those cuts, you still have to readjust the Gramm-Rudman target upward about $30 billion, if I recall the figure, in order to make it all work.

So, I don't know where this big increase is going to come from.

Gentlemen, you have been very generous with your time. We may have other questions for the record. Is there anything—like we used to say, for the good of the order—that anyone would like to say before we close it down?

Dr. HECKER. I appreciate your time.

Mr. OFTE. Thank you.

Senator JOHNSTON. Thank you.

ADDITIONAL PREPARED STATEMENTS FOR THE RECORD

Now, before we conclude, I understand we have prepared statements from Assistant Secretary for Nuclear Energy, David Rossin, and Ben Rusche, Director of the Office of Civilian Radioactive Waste Management, which I want to make part of the record at this point.

[The statements follow:]

STATEMENT OF A. DAVID ROSSIN, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. Chairman, I am pleased to have this opportunity to discuss the Department of Energy's program and fiscal year 1988 budget request for its Nuclear Energy Supply Research and Development (R&D) and Uranium Enrichment activities.

The requested funds are distributed among program elements as summarized in the following table:

	----($ in Millions)----	
Program Element	FY 1987 Appropriation	FY 1988 Request
Energy Supply R&D		
Nuclear Energy R&D	$ 327.6	$ 334.2
Remedial Action and Waste Technology	$ 276.9	$ 251.5
Policy and Management	$ 1.8	$ 2.2
TOTAL	$ 606.3	$ 587.9
Uranium Supply & Enrichment Activities		
Uranium Enrichment Activities	1,106.4	1,070.0
Reserve	104.0	0
Uranium Enrichment Revenues	-1,286.4	-1,301.0
Net Uranium Enrichment	$ -76.0	$ -231.0

Detailed funding tables are included in the discussion of each major program.

OVERVIEW

The National Energy Policy Plan identifies nuclear energy--in addition to coal and conservation--as one of the key elements of an energy triad required to provide Americans an adequate supply of energy at reasonable cost. This Administration remains strongly committed to ensuring that nuclear power can continue to be a vital contributor to the energy security of the nation. Each of our major program areas--reactor development, remedial actions and waste technology, and uranium enrichment--is sharply focused on achieving this objective. Our space and defense nuclear energy activities, as well as portions of our advanced nuclear systems and uranium enrichment activities, also support important national security objectives.

Another objective of mutual interest to both Congress and the Administration is reducing the Federal budget deficit. Accordingly, both the content and pace of each major program area in the Department's FY 1988 budget request has been tempered by the overriding concern for fiscal restraint.

I will briefly touch upon the highlights and key factors that influenced the budget request for each of our programs.

The Department's FY 1988 budget request for Nuclear Energy R&D activities provides funding for four major program areas--Light Water Reactors (LWRs), Advanced Reactor R&D, Space and Defense Power Systems, and Advanced Nuclear Systems (ANS). The budget request also funds the facilities and management required to implement these programs. The first two--LWRs and Advanced Reactor R&D--constitute the Civilian Reactor Development Program. The latter two programs develop power sources for U.S. military and civilian space and terrestrial missions on a cost-shared basis with the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD).

These two major program areas--civilian reactor development and the development of power sources for space and defense purposes--are of vital importance to the nation. Each is managed and funded separately within the Department's Office of Nuclear Energy. Within the existing fiscal constraints, the Department's FY 1988 budget request strikes a balance that yields two lean, goal-oriented efforts. In this FY 1988 budget request, we have attempted to strike a reasonable balance between these two program areas in light of budget constraints. In so doing, certain space and defense energy efforts in FY 1988 have been reduced below levels projected last year and anticipated by our DOD and NASA partners.

The Civilian Reactor Development program has been focused from a multi-path strategy down to a more narrow approach. This approach is based on two distinct goals for two distinct timeframes--first, to support a coordinated Department of Energy (DOE)/industry effort to enable utilities to order reactors by the early 1990s; and, second, to develop the most promising alternative reactor system and its fuel cycle so that a competing technology will be available in the marketplace by the end of the century.

The logic, strategy, and major milestones to achieve these goals are contained in the strategic plan for the DOE Civilian Reactor Development Program, which was first published for comment in October 1985 and is currently being revised to reflect events in the intervening period and comments from the Energy Research Advisory Board (ERAB) and other reviewers.

The problems facing nuclear power in the near-term include the need for resolving several significant institutional difficulties and updating the technology for the continued safe and reliable operation of nuclear powerplants. This includes developing simplified designs with enhanced safety for the future. Lengthy and unpredictable Federal safety and licensing regulation, new versions of State economic regulation, nuclear indemnification insurance, and even greater problems with public perception are but a few of the obstacles that must be remedied. The Department continues to pursue vigorously--in cooperation with Congress and industry--appropriate means to solve these problems. Only by satisfactorily resolving these institutional issues can nuclear power once again be judged fairly in the marketplace on its safety, economic, and environmental merits.

The state-of-the-art LWR still represents the best avenue to revitalize the nuclear option so that new additions to nuclear power production can be operating before the end of this century.

Thus, the program focuses on supporting industry efforts to accomplish three objectives:

- improve the operation and availability of current LWRs;
- derive maximum benefit from plants under construction; and
- obtain Nuclear Regulatory Commission (NRC) certification of at least two advanced LWR designs that could be ordered by 1991, without construction of any demonstration plants.

This third objective, the Advanced Light Water Reactor (ALWR) program, was initiated in 1986. The ALWR program is the cornerstone of DOE efforts that complement larger industry-funded efforts to achieve these objectives. In each task, the industry contribution equals or exceeds that of DOE.

The Advanced Reactor R&D program goal is to develop the most promising alternative reactor system. The program is focused on modular, liquid metal-cooled reactor (LMR) designs. The reasons for focusing on the LMR are four-fold:

- the LMR can become a viable alternative to LWRs around the turn of the century, providing additional passive safety features, needed flexibility and diversity in modular additions at a particular site, lower per unit capital commitments, and shorter lead times;
- because most of the Department's nuclear R&D facilities are oriented toward liquid metal systems, focusing on the LMR will allow facility consolidation and cost reduction at the earliest prudent date;
- emphasis on a single advanced reactor technology beyond ALWRs permits pursuit of a meaningful technical program within budget constraints; and,
- the LMR offers the best path to meeting the long-term strategic objective to extend the uranium resource.

The High Temperature Gas-Cooled Reactor (HTGR) development continues at a pace and funding level appropriate to its stage of development, scope of active international program interest, and market level interest. We will continue in FY 1988 to work on some key fuel technology issues through jointly-funded international programs. Once an NRC licensability statement is obtained in 1987, the modular HTGR concept will have been adequately developed to permit its evaluation by the marketplace for central-station power generation. For that application, HTGR development should be pursued through private sector support and international collaboration. The potential market for high temperature process heat applications is uncertain and far in the future. The Department considers it unnecessary to optimize the HTGR further for that purpose now or justify its program on the potential for nuclear-generated process heat.

The Space and Defense Nuclear Power Systems program charter is to meet the energy requirements of NASA and DOD missions; the majority of the funding for the projects included in this program comes from these user organizations. The Department's FY 1988 budget request totals $96 million, while the sum of the NASA and DOD contributions are expected to be about $125 million. The principal reason for the increase in funding (from $48.3 million in FY 1987 to $96 million in FY 1988) is that certain projects have advanced closer to providing hardware to meet user requirements. This is particularly true in the Strategic Defense Initiative (SDI)-related SP-100 space reactor project, where a contract is in place leading to construction of the ground engineering system demonstration reactor and completion of testing by mid-FY 1992. Even at this funding level, which is less than forecast last year, the pace of several key programs (such as the Multimegawatt Space Reactor program) to support SDI is deferred.

The Advanced Nuclear Systems program will emphasize additional pre-launch safety testing of Radioisotope Thermoelectric Generators (RTGs), maintenance of the RTG production capability, development of advanced RTGs to meet future, planned missions, special tests made possible by the delay in the Galileo and Ulysses missions, and delivery of RTGs for the Special Applications program.

The objectives of the Remedial Action and Waste Technology Program are to stabilize radioactive wastes or perform decontamination and decommissioning at contaminated DOE and legislatively-authorized non-government facilities and sites; facilitate development of a reliable national system for managing low-level radioactive wastes; and develop beneficial uses of nuclear waste byproducts. Successful execution of this program is a key part of the Department's commitment to meet environmental standards in connection with its current and previous activities. The overall limitation on Government spending must also be applied in the Remedial Action program. This will have the impact of extending the completion dates for certain projects and, therefore, ultimately causing some increase the total cost of the program. Consistent with the guidance contained in House Report No. 99-195, DOE will propose to extend the 7-year authorization period of the Uranium Mill Tailings Remedial Action (UMTRA) program through FY 1993.

Congress has consistently recognized that energy security and national security provide strong motivation for maintaining an efficient, stable, competitive uranium enrichment capability in the United States. Domestic employment and energy security are bolstered by a secure, reliable, and economical supply of enriched uranium, safe from the threat of foreign supply disruptions or price controls. Our commercial sales to foreign utilities aid in the Nation's balance of trade payments and contribute to the nation's nuclear nonproliferation efforts through our involvement in the nuclear fuel cycle. Finally, important national security objectives are supported by the availability of a safe, dependable supply of highly enriched uranium at reasonable costs for U.S. naval forces and defense needs.

In 1984, the Department adopted a three-part strategy to revitalize the uranium enrichment enterprise. The major elements of that strategy are, first, to reestablish a stable market via the Utility Services contracts and aggressive marketing initiatives; second, develop minimum cost approaches to meeting customer demand; and, third, restructure the enterprise as required to assure long-term stability. While the Department has successfully executed the first two elements, much remains to be done to restructure the enterprise. DOE has concluded that the enrichment enterprise can best meet its commercial obligations and challenges if it is restructured as a Federally-chartered corporation, with eventual public ownership of the corporation's stock. We are eager to discuss this proposal further with the Subcommittee in the days ahead and work with the 100th Congress to structure enabling legislation that can implement this recommendation in 1987.

More detailed discussion of these factors and the scope, status, and budget request for all programs is contained in the sections that follow.

NUCLEAR ENERGY RESEARCH AND DEVELOPMENT

The funding request for nuclear energy R&D programs is contained in the following table:

	----($ in Millions)----	
Program Element	FY 1987 Appropriation	FY 1988 Request
Nuclear Energy R&D		
Light Water Reactors	$ 34.0	$ 34.0
Advanced Reactor R&D	75.5	70.7
Space/Defense Power Systems	48.3	96.0
Advanced Nuclear Systems	20.6	22.0
Facilities	127.8	103.0
Water-Cooled Breeder	13.8	0.0
Program Direction	7.6	8.5
Total	$ 327.6	$ 334.2

LIGHT WATER REACTORS

There are currently more LWRs in operation in the United States than in any other country. These reactors are generating over 16 percent of the Nation's electricity and have reduced our dependence on imported oil. Between now and 1992, 13 additional units are scheduled to begin operation.

The drop in load growth since the mid-1970's left the Nation with excess generating capacity. This fact, combined with inflation and a variety of institutional problems, has resulted in the cancellation of numerous plants, some well advanced in construction. No plant ordered after 1973 has gone into operation or is still being built. While U.S. plant orders have stopped, the nuclear programs in such industrial nations as France, Japan, and others have advanced steadily. As a result, there has been worldwide progress in both LWR technology and deployment during this period of stagnation in the United States. The tragic accident at the Chernobyl atomic power station in the Soviet Union has caused all nations to reexamine the safety of their nuclear powerplants. Some nations have announced delays, but most are holding firm on their civilian power programs.

In spite of economic problems in the U.S. nuclear industry, the industry continues to make large investments toward improving current plants. In addition, they are developing designs for ALWRs which employ the best technology available worldwide.

Carefully designed, simplified LWRs are the most practical and realistic vehicle for the revitalization of the nuclear option in the United States. The utilities and suppliers know these designs (both strengths and weaknesses) and know what improvements have to be made. Not only will this improve operability and economics, but it will raise public confidence in these machines and their operations. The Department's program in FY 1988 is closely coupled to industry's efforts so that the benefits of advanced, state-of-the-art standardized LWR designs can be brought to fruition. Joint program reviews are held and DOE contracts call for substantial cost sharing--at least 50 percent.

To restore a viable LWR option that will help to meet the electrical load growth and replacement capacity requirements of the 1990's, three key requirements--among others--must be satisfied. First, plants must be designed to provide enhanced safety and reliability, and at the same time, be economically attractive. Second, the designs must be acceptable to the electric utility industry. Third, the designs must be certified by the NRC.

A key milestone towards the availability of these standardized LWRs is obtaining NRC certification of at least two ALWR systems by the early 1990's. The pursuit of this objective will serve to focus and guide the Department's efforts in this area.

ADVANCED LIGHT WATER REACTOR PROGRAM

Initiated during FY 1986, the Department's ALWR program has been developed in close cooperation and coordination with the Electric Power Research Institute (EPRI) ALWR Program, sponsored by the electric utility industry. The Department's ALWR program includes three key activities: (1) support for the EPRI/industry program of defining technical requirements for ALWRs; (2) working cooperatively with industry for certification of at least two ALWRs to demonstrate resolution of technical issues; and (3) performance of a technology program on innovative features of mid-sized LWRs to support the EPRI/industry program.

The first activity involves support for the utility industry's generation of detailed requirements for future LWRs. Notwithstanding the contributions that have been made by nuclear power to date, there are several areas where additional advances in technology are possible that will take advantage of the experience that has been gained from the research, design, construction, operation, and regulation of these plants. The future designs will have the following characteristics:

- Simplified and reduced numbers of systems and components.
- Use of more passive safety features.
- Lower accident probabilities.
- Higher constructibility, availability, maintainability, and operability.
- Completion of design and engineering testing.

Although the requirements program is primarily an industry activity, the Department is assisting in the severe accident area and by general review to assure safety and reliability.

The second activity includes support for NRC safety reviews of two large (1,250-1,350 megawatt electric, or MWe) standard plant designs--an advanced boiling water reactor design and an advanced pressurized light water reactor design. Good progress is now being made in establishing the NRC review process, coordinating with the EPRI/utility industry requirements and criteria, and initiating the preparation of required safety analysis evaluations and reports. In 1988, we expect that most of the safety analysis reports will have been submitted for NRC review as a part of the process leading to licensing. The objective is that these plant designs will be NRC-certified in 1991. Certification means that the NRC would license the plant design at an approved site without additional safety review.

In the third area, technology development support is being provided for two mid-sized (600 MWe) plant concepts--a boiling water reactor design and a pressurized light water reactor design. These plants offer the opportunity to incorporate further evolutionary changes to LWRs which are highly desirable, provided they can be achieved in realistic designs. Designs are being developed which will not only build on the extensive experience base from the last three decades of reactor operation, but which also take advantage of potential simplifications and innovations in design and construction that are unique to their smaller power rating--such as the application of more passive safety systems or the use of modularization to improve construction. With today's pattern of modest load growth rates and the current economics of plant construction, plants that offer lower capital cost and substantially reduced construction periods also offer a promising alternative in meeting utility needs. Over a 3-year period, our program will help to demonstrate the efficacy of these designs through the support of concept development and verification testing of key features. In all of this work, the DOE and EPRI/industry ALWR programs are complementary and mutually supportive. This program will make a significant contribution toward making nuclear power an option for utilities once again by providing safe, reliable, and economically viable LWR designs. These designs can become standardized plants once they are certified by the NRC. We cannot predict the precise year when new power plants will have to be ordered, but the Nation needs to ready when that day comes.

SAFETY AND LICENSING SUPPORT

There are three areas in this program subelement that specifically support the Department's ALWR activities as well as addressing issues associated with current plants. The three areas deal with severe accidents, plant life extension, and other critical institutional concerns.

Resolution of severe accident issues is a major activity to be addressed in safety reviews of ALWRs. Certainly the Chernobyl accident has heightened awareness of this topic. One aspect of the Department's severe accident program is to apply its contractors' expertise in this area to identify potential design requirements that may result from the resolution of severe accident issues. Through the Utility ALWR Requirements Program, interactions will take place with the NRC to reach agreement on the approach needed to resolve severe accident issues.

Included in this activity for FY 1987 is the application of analysis codes that incorporate the extensive findings of DOE and NRC-supported research over the past several years. Transfer of calculational methods, to vendors who are involved in the ALWR large plant certification activities, is also being provided under this severe accident assessment program. In FY 1988, resolution with the NRC of severe accident issues will take place in accord with the approaches agreed upon in FY 1987. Development of the engineering bases in support of the Utility Requirements Document will be completed. Severe accident analysis support will continue to be provided to the ALWR vendors making applications to the NRC for design certification.

In FY 1987, the loss-of-fluid test (LOFT) reactor was deactivated. Analyses of the Soviet reactor accident at Chernobyl were also performed as part of the U.S. contribution to an international consensus report on the accident. For FY 1988, additional post-test examinations will be performed on fuel from severe damage tests that have already been conducted. Test information on source term and containment integrity issues will also be obtained.

Plant life time activities support current operating plants, DOE-owned reactors, and are useful in the ALWR program. To help assure early implementation, the initial emphasis has been on operating plants. The potential for extending the life of current reactors looks very favorable; however, the criteria and technical bases for such extensions are not yet clarified for either designers or regulators. In FY 1987, the Department will be cooperating with industry and the NRC in the development of regulatory criteria and bases that extend life beyond current regulations that arbitrarily limit a license to 40 years. With respect to ALWRs, the Utility Requirements Document calls for a 60-year life. The data being developed will serve as a technical basis for extending the current 40-year license.

TMI-2 ACCIDENT EVALUATION PROGRAM

During FY 1987, TMI-2 research and operations are directed toward the removal and shipment of core debris to the Department's Idaho National Engineering Laboratory (INEL) and further understanding of the March 1979 accident scenario.

The GPU Nuclear Corporation (GPU Nuclear) plans to complete defueling of the core debris by the end of 1987 and complete the shipment of about one-half of the core debris by September 1987. GPU Nuclear expects to complete the recovery program and place the plant in a safe monitored condition by the end of 1988.

Removal and shipment of the core debris is a joint effort shared by DOE and GPU Nuclear. DOE will maintain shipping on a schedule consistent with core material availability.

The TMI-2 Accident Evaluation Program made progress in the areas of sample examination and accident evaluation during FY 1987.

DOE issued a revised accident scenario that incorporated observations from core bores that penetrated through the rubble to the bottom of the core. Additional information on fission product distribution and more detail on the condition of the lower core will be obtained as debris is removed and the lower regions of the vessel are exposed to allow direct examination. A large number of samples of core debris were shipped to participating Nuclear Energy Agency (NEA) international members for extensive examinations. These results will be coordinated and integrated with the examinations being carried out by DOE and the NRC.

Under the TMI-2 program, DOE has made information and findings available to industry in the areas of nuclear powerplant circuit diagnostics, through EPRI; waste management standards, through the United Nations-sponsored International Atomic Energy Agency; and reactor safety research, through the NRC.

During FY 1988, the shipment of fuel from the TMI-2 site to INEL will be completed and a final revised accident scenario incorporating the results from the NEA program will be prepared. This will include the observations made during the lower vessel defueling and DOE sample examinations.

ADVANCED REACTOR RESEARCH AND DEVELOPMENT

The goal of our Advanced Reactor R&D program is to develop modular liquid metal-cooled and modular gas-cooled reactor systems that can meet evolving market needs while providing a path to long-term energy security and resource extension.

Both LMR and HTGR systems can contribute to electricity generation requirements for new capacity that are forecast near the turn of the century. LMR systems also provide a technological path to resource extension, a strategic objective affecting the Nation's long-term energy security. The LMR system meets the long-term goal through improved uranium fuel utilization efficiency (a 50-fold increase over the once-through cycle used in current reactors).

Improved economics is an important objective of the Department's program. Improvements in public acceptance, safety margins, and plant reliability and performance are additional objectives of the advanced reactor systems. For these objectives to be met, assurance of plant shutdown and adequate decay heat removal capability in response to off-normal events will be key factors for the advanced designs. Research and development accomplishments over the past several years give confidence that these objectives can be met in a cost-effective manner.

The Department does not expect to build an advanced reactor demonstration plant solely with Government funds.

Utility/industry associations ensure that the Government receives timely utility and industry information on plans, requirements, and future energy trends. Information developed by industry and the Federal Government will be incorporated into the Department's R&D program. Support for the construction of first-of-a-kind advanced reactor system must be provided by the private sector, with any future Government role to be evaluated with respect to national priorities in the 1990's.

In FY 1988, we will continue to improve our facility productivity and consolidation of test facilities. Fee schedules will be applied for cost-shared programs.

The Advanced Reactor R&D program is organized into three major areas, supported by essential test facilities: (1) LMR design; (2) LMR technology, which includes fuels and materials; and (3) HTGR design and technology. International collaboration cuts across all three program areas, permitting U.S. access to large, mixed oxide-fueled breeder plant construction and operating experience at minimal program cost and allowing cost-sharing for the development of DOE innovative designs in areas of common interest. DOE supports international activities (generally on a 50/50 cost-sharing basis) in LMR design and technology, oxide fuel cycle, and HTGR R&D.

Improved economics, safety margins, and plant performance can come about only through new reactor plant designs and a stabilized, predictable licensing and regulatory process in the United States. The FY 1988 program continues to build upon past accomplishments and aims toward the goal of selecting one modular LMR design for development. The chosen LMR concept will undergo preliminary and detailed design beginning in early FY 1989. The completed design will permit private sector evaluations of market potential and could provide the basis for a private industry cost-shared safety and operational demonstration of the reactor system.

Both LMR and HTGR reactor systems incorporate advanced features necessary to secure the benefits discussed above--modular, standardized designs to lower costs; factory fabrication to stabilize site construction costs and improve quality assurance and control; a range of capacity sizes (obtained by combining standard modules) to meet a variety of utility load growth and financial requirements; advanced control systems to improve reliability and operator response; and passive safety systems. These rely on physical and neutronic properties of reactor fuels and materials to protect against reactor power transients and loss of coolant flow rather than on rapid operator response and multiple engineered systems used in conventional plants.

LMR DESIGN

Two modular LMR designs, the Power Reactor Inherently Safe Module (PRISM) and the Sodium Advanced Fast Reactor (SAFR), are currently underway. The design R&D work begun in FY 1985 will be concluded by the first quarter of FY 1988. Criteria for the selection of a reference design will ensure that any future plant meets the requisite economic and safety standards.

Progress on the current designs is encouraging. Recent landmark safety tests demonstrated that the liquid metal-cooled Experimental Breeder Reactor II (EBR-II), using metallic fuel, returns to a safe state from full-power following both loss-of-coolant pumping and loss-of-normal heat sink, both coupled with a simultaneous simulated failure of all control rods to scram the reactor. This safe shutdown condition was achieved without operator intervention or action, engineered components, and relied only on physical properties of the coolant and fuel. Initial reviews of the two advanced conceptual designs have been conducted by the NRC. Preliminary safety information documents were submitted to the NRC in the first quarter of FY 1987. These documents are being reviewed by NRC staff and will lead to issuance of Safety Evaluation Reports and licensability letters in early 1988. In addition, early NRC positions will be developed from NRC policy papers on such issues as containment, severe accidents, and standardization. Recent analyses of both designs provide an expectation of achieving competitive costs and a 3- to 4-year-per-module construction period.

The FY 1988 budget request for LMR design activities would fund essential trade-off studies to support the selected concept and to incorporate passive safety features into the advanced reactor designs. These safety features reduce even further the likelihood and consequences of plant equipment failures.

LMR TECHNOLOGY

The Department's budget request for LMR technology efforts supports the design of a standardized, modular plant that can be largely shop fabricated. FY 1988 technology activities are primarily in the areas of testing key plant features and components; developing advanced plant instrumentation and control systems, shielding and structural materials; fuel performance testing, core design efforts and preparing the safety analysis for a Fast Flux Test Facility (FFTF) metal-fueled core.

The metal fuel cycle offers potential benefits (when compared to oxide fuel) through improved fuel cycle technology and economics, fuel performance, and potential for passive safety design. Metal fuel R&D capitalizes upon the low vapor pressure and good neutronic properties of sodium cooling and metal fuel to achieve breakthroughs in safety and fuel cycle economics. Metal fuel will be the reference fuel for the selected design concept. The ERAB Special Panel on Advanced Reactor Development considers the development of the metallic fuel and associated pyrometallurgical reprocessing and waste management technology a high priority.

The Department's budget request has focused on demonstrating the safety characteristics and performance of metal fuel; establishing technical and economic feasibility of pyroprocessing and of both U-Pu-Zr and U-Zr fuel fabrication processes (through laboratory scale demonstration); optimizing core designs, developing prototypic equipment systems for a planned fuel cycle demonstration; and validating technical performance computer codes.

The lead test on new alloy U-Pu-Zr fuel has achieved 100,000 megawatt-days-per-ton (MWD/MT) burnup as of January 1987, and irradiation to cladding breach is continuing. This represents about two-thirds of the burnup goal for application of this fuel system to the modular LMR. Feasibility of electrorefining and halide slagging processes has been demonstrated on a pilot scale, and the construction of an engineering scale electrorefining demonstration facility is nearing completion. Passive safety potential has been demonstrated in two landmark tests conducted at EBR-II last April--loss-of-flow without scram and loss-of-heat-sink without scram. A commercial-size, integral fuel cycle facility has been designed and has been cost estimated. A conceptual design has been completed for refurbishment of the original EBR-II Fuel Cycle Facility, now called HFEF-South.

Sufficient inventory of FFTF oxide fuel will be retained as the backup fuel to the metal fuel cycle until FFTF conversion to metal fuel can be completed. The oxide fuel Core Demonstration Experiment (CDE) will continue. The CDE will confirm a 3-year lifetime for oxide fuel. Continuation of the test also will extend the date by which the current inventory of oxide driver fuel is depleted.

A program for long-term reprocessing collaboration with the Japanese Power Reactor and Nuclear Fuel Development Corporation (Japan-PNC) was initiated in January 1987. Other collaborative efforts in this area with the United Kingdom, France, and the Federal Republic of Germany (FRG) will continue. Through the Japan-PNC program, work will continue in FY 1988 at the Oak Ridge National Laboratory (ORNL) on advanced remote systems and robotics applicable to U.S. LMR requirements. The initial R&D phase with Japan-PNC may be followed by a design and operation phase during which ORNL-developed technology could be demonstrated in a hot operating facility in Japan. Collaboration with other partners in FY 1988 and beyond will focus on data and information exchange, consistent with available funding and the new Japan-PNC agreement.

MODULAR HTGR

The modular HTGR has the potential to produce electricity in an economical, safe and environmentally acceptable manner and has the potential to produce industrial process heat. Scarce oil and natural gas could be conserved as a result.

The Department's HTGR strategy relies on international collaboration and private sector support to assist with the technology development needed for successful deployment. Following completion of the modular HTGR conceptual design later this year, relatively limited technology demonstration efforts will remain.

In FY 1988, international programs will continue with Japan, West Germany, and Switzerland in technology development activities. Fission product transport tests in the French COMEDIE reactor will be underway. Foreign gas-cooled reactor programs emphasize process heat applications and provide the U.S. with an opportunity to continue HTGR development on a cost-shared basis. The FY 1988 budget request supports HTGR development within a cooperative international program, including fuel, fission product behavior, graphite studies, and materials testing.

SPACE AND DEFENSE NUCLEAR POWER SYSTEMS

The Space and Defense Power Systems program is a major, expanding, and important element of the Department's Nuclear Energy R&D effort which responds to requirements for nuclear energy sources identified by NASA and DOD, including the Strategic Defense Initiative Organization (SDIO). Program activities include the design, development, and technology support for building and testing compact, high performance reactors for space and terrestrial applications, and dynamic isotope power systems for space application. The program is comprised of four firm projects--the SP-100 Space Reactor, the Multimegawatt (MMW) Space Reactor Program, the Dynamic Isotope Power System (DIPS), and the Small Nuclear Power Source Demonstration Project (SNPSD), plus a fifth--the Multimegawatt Terrestrial Powerplant--where the Air Force is currently reevaluating its needs and plans. These projects are intended to operate in remote and demanding environments, independent from logistical supply chains. In many cases, they represent the only power sources capable of fully meeting user mission requirements.

The Department has undertaken these nuclear energy projects to meet expanding space and defense requirements as part of its overall nuclear development charter in the Atomic Energy Act to support other Federal-agency as well as civilian energy needs. In each case where DOE is proposing funding, it is because NASA or DOD has requested DOE to work with them to develop or provide a power source for a specific requirement. In all cases, these projects are cooperatively funded by DOD or NASA in accordance with joint project agreements, with the user agency contributing at least 50 percent of the total project cost over a period of years. In FY 1988, this funding generally matches or exceeds the DOE budget request. For example, the Department's FY 1988 budget request for the five projects that comprise the DOE Space and Defense Nuclear Power Systems program totals $96 million, while

DOD funding estimates for these same projects is approximately $125 million.

The funding requested by the Department for these projects increases from $48.3 million in FY 1987 to $96 million in FY 1988. This growth is at a lower rate than forecast last year in order to better balance the funding between civilian programs and space and defense programs within total budget constraints. Given the recent budget reductions for this program in FY 1987 Congressional Appropriations and the reduced FY 1988 requests, the scope and pace of these programs will, unfortunately, be slowed compared to initial plans developed with the users.

The reason for the increase in FY 1988 is that most of the projects have progressed to a new stage, bringing each closer to becoming "hardware" to support a need date identified by the user. For example, the SP-100 program, which was funded in FY 1987 by DOE at $27 million and will be funded by DOD in the $35 million range, has now completed its technology assessment and advancement stage. During the current SP-100 ground engineering system development and demonstration testing phase, DOE will design, build, and ground test a reactor and its power conversion subsystems over the next 5 years. The advanced design work leading to construction and preparations for ground testing that will be fully underway by FY 1988 will obviously require more funds than the technology development and planning activities that were conducted in FY 1987; accordingly, the DOE funding request has increased from $27 million to $70 million. The corresponding DOD cost-shared contribution for FY 1988 is $81 million. The same scenario of project growth and transition applies to other projects, e.g., the MMW Space Reactor (whose need date and, therefore, its development is 5 to 6 years behind that of the SP-100 reactor) and the Dynamic Isotope Power System to be used for the Boost Surveillance and Tracking System (BSTS) in the early 1990's.

An additional key point regarding the funding levels for the Space and Defense Power Systems program is timing. For example, if the SP-100 reactor system is to be available and proven by the early- to mid-1990's as desired by DOD, and if we are to be in a position to select one multimegawatt space reactor concept by 1991 or 1992, then certain activities must be conducted now. The funding we have requested in FY 1988 is the amount needed to conduct all of these activities and to maintain a schedule commensurate with DOD's needs. Lower funding levels will simply not permit delivery of the various power sources by the desired need dates with the necessary confidence in the technology.

SP-100 SPACE REACTOR PROJECT

The SP-100 Project began in February 1983 as a joint endeavor among the Departments of Defense and Energy and NASA. Its establishment marked the reemergence of efforts in the U.S. to assess, develop, demonstrate, and ultimately make space reactor power system technology available for a broad class of military and civilian space mission applications when needed in the 1990's and beyond.

The SP-100 Project is specifically focused at space-based electrical power requirements up to about 1 megawatt. The project consists of three phases: Phase I, "Technology Assessment and Advancement," (FY 1983-1985); Phase II, "Technology Flight Readiness," (FY 1986-1991); and Phase III, "Flight System Production, Qualification, and Application."

Phase I was successfully completed with the selection of the reactor thermoelectric concept, the selection of an existing, contained facility the DOE Hanford Reservation as the preferred reactor test site, and the establishment of a reference mission involving a 300 kilowatt electric (kWe) reactor system with electric propulsion units. The project is now in the second year of the 6-year Phase II effort. This phase is comprised of four functional elements, with each participating agency having responsibility for one or more of the functional elements. Specifically, the SDIO is responsible for SP-100 Military Mission Analyses and Requirements Definition, and is using the U.S. Air Force (USAF or Air Force) as its executing agent. NASA is responsible for SP-100 Civil Mission Analyses and Requirements Definition, as well as for pursuit of SP-100 Advanced Aerospace Technology. DOE is responsible for SP-100 Ground Engineering System (GES) development and demonstration testing.

Other potential applications include nuclear electric propulsion orbital transfer vehicles for the Global Positioning Satellite (GPS) constellation, prime power for the Space Surveillance and Tracking System (SSTS) mission, power for the Neutral Particle Beam (NPB) discriminator and Space-Based Radar (SBR) missions, nuclear electric propulsion as well as prime power for NASA planetary missions, and power for the NASA evolutionary space station.

The mission analyses over the past year have indicated that the most likely near-term missions will be in the 100 kWe range or lower, rather than in the 300 kWe range and above. This is true for both SDIO and non-SDIO military missions. Recognizing the earlier focus on power levels less than 100 kWe, the Tri-Agency SP-100 Steering Committee decided to change the reference power level from 300 to 100 kWe, keeping certain key design analyses and features consistent with the 300 kWe level. This will allow the SP-100 GES test to be more prototypical of the near-term missions, but it will also establish the technology readiness and safety features for higher power levels.

The SP-100 GES development contractor was selected by DOE last August. A letter contract was signed with the DOE contractor last September; subsequently, a definitive contract was signed on December 30, 1986. The GES effort, including this contract, represents the largest and most important activity of Phase II efforts. The contract package contains extensive definition of the requirements to be placed on the SP-100 space reactor power system and the details of the contractor tasks required to accomplish the SP-100 GES objectives. In addition, the contract includes, as an option, production, qualification, delivery, and integration of a flight unit as well as the necessary support to launch and operate the first SP-100 power system in space.

The SP-100 GES development contractor is now working to complete the reference flight system design. Subsequently, in FY 1988, the contractor will translate that design into a GES design for ground testing and then fabricate the components, subsystems, and major assembly hardware items for lifetime and performance testing to validate the reference flight system design by mid-FY 1992. The first major deliverable is the reference flight system design; that design review is scheduled for the fourth quarter of FY 1987. This will lead to a GES reactor design freeze by early FY 1989, with the reactor being built during FY 1989 and FY 1990 and ground tested in FY 1991.

Extensive site planning as well as conceptual facility modification design activities have been undertaken to identify work required to meet the GES reactor test schedule and test program objectives. Overall, test facility conceptual design is now more than 80 percent complete, with full completion scheduled to occur in March 1987. Premodification test facility cleanup is about 80 percent complete. Environmental and safety compliance is of major importance to this testing effort. An initial determination has been made by DOE that, for this existing facility, an Environmental Assessment is the appropriate documentation required under the National Environmental Policy Act (NEPA) for the planned reactor ground test. That Environmental Assessment has been drafted and is now under review.

In addition to the reactor ground test, an integrated system-level assembly test of the space power system, using an electric heat source instead of an operational reactor, will also be conducted in FY 1991. This integrated assembly test will not only demonstrate thaw of the lithium coolant, but also the performance of the thermoelectric power conversion subsystem, as well as structural, mechanical, electrical, and thermal integration of the entire power system. This test, like the reactor ground test, will be conducted in a temperature-controlled vacuum vessel to simulate the space environment.

In order to meet the challenging SP-100 GES project schedule and requirements, it is necessary to sustain several ongoing activities. Such efforts include fuel and materials development and characterization, safety analysis and testing, and fuels and materials irradiation testing. To date, very substantial accomplishments have been achieved in these important areas and these efforts must continue through FY 1991 to ensure that an adequate engineering data base is established and to validate the lifetime and safety of the system.

MULTIMEGAWATT SPACE NUCLEAR POWER PROJECT

The objective of the MMW Space Nuclear Power Project is to identify at least one space nuclear power system concept by 1991-1992 that meets SDI power requirements and to resolve technical and safety feasibility issues for that concept.

The project covers development of the total nuclear electrical power supply system and supporting technologies for SDI space-based platforms that require multimegawatts of electrical power. The necessity for developing nuclear power systems is primarily driven by the stringent requirements imposed by operating space-based defense weapons such as the Neutral-Particle beam, the Electromagnetic Gun or the Free Electron Laser, and surveillance and monitoring platforms. These requirements (depending upon the chosen SDI architecture) will include megawatts of continuous or semi-continuous power for alert mode operation (intermittent duty with a 1-year integrated lifetime), and hundreds of megawatts for burst mode operation (hundreds to a few thousands seconds). Rapid transition from alert to burst mode of operation is also required.

Nuclear systems, as opposed to chemical systems, are the only realistic option to provide steady-state (continuous and alert) power needs because of the excessive mass of fuel required for chemical systems. Nuclear systems also compete favorably with nonnuclear power systems for burst power applications requiring bursts of more than several hundred seconds. Lower mass and volume, enhanced survivability, increased reliability and maneuverability, and lower life-cycle costs are also potential advantages of nuclear systems.

The MMW project involves two major parallel but interactive activities. The first is the definition and conceptual design of promising nuclear power system concepts. The second is the identification and advancement of technologies and resolution of critical technology feasibility issues.

The scope of the concept design activity covers development of the total nuclear electrical power supply system, which includes the following subsystems; the energy source (i.e. reactor); radiation shielding; heat transport and rejection; power conversion; energy storage; and power conditioning and control. Concepts received from industry and government laboratories to date can be categorized into three main reactor classes: gas-cooled reactor systems; thermionic reactor systems; and liquid-metal cooled reactor systems.

The technology activity will be focussed on resolving critical technical feasibility issues related to candidate concepts. The technology areas being pursued reflect the range of current candidate concepts. Initially, technologies that directly support more than one concept have been given highest priority for development. When compared to SP-100, MMW systems may require higher operating temperatures, higher fuel burnup, and higher neutron fluence levels, all of which impose strict requirements on reactor fuels and materials. Heat transport systems need to be developed for the higher operating temperatures, longer lifetimes and potentially severe power transients in duty cycles. Significantly higher power production and heat rejection rates will demand radiators and energy conversion systems with very low specific weights. Energy storage systems may need to be provided for burst mode operation without producing a significant weight penalty. Finally, the higher temperatures and radiation levels will require high-temperature radiation shields, reactor controls, and hardened electronic materials.

Based upon the imposed reductions in the FY 1987 MMW budget, a different approach and extended schedule for the narrowing of concepts will be used. The ongoing laboratory and industrial concept work will be refocused to prepare data packages that will be used to support a subsequent Request for Proposal (RFP) process. The data packages will be available to industry to help them respond to the RFP and develop totally integrated MMW space power supply concepts, particularly in terms of satisfying both alert and burst mode requirements. Contracts will be awarded early in FY 1988 to an appropriate number of industrial teams for a limited 6-month Phase I effort. That effort will concentrate on initial system concept development and identification of concept-specific technologies. Subsequent downselection to 2 or 3 candidate systems in early FY 1989 will initiate Phase II.

In support of the technology activities, FY 1988 funds will be used to continue development of fuels and materials technologies. Irradiation tests will be initiated in FY 1988 to allow sufficient time so that typical burnups are achieved and post-irradiation examination is completed prior to concept downselection to one candidate in 1991 or 1992. In addition, SP-100 safety planning efforts will build upon existing safety analyses specifically applicable to the MMW project. The SP-100 safety requirements and criteria will be reexamined and modified for the MMW project.

Included within the overall MMW project but managed as a separate element is the Thermionic Fuel Element (TFE) Verification program. This program evolved out of the SP-100 concept selection process to answer questions that precluded thermionic concept selection. The purpose of the program is to demonstrate and verify the technology readiness of a TFE suitable for use as a basic element in advanced thermionic reactor concepts with electrical power output in the 0.5 to 5 MWe power range and a 7-year lifetime. The program approach includes verification of a 7-year operational lifetime for TFE components by accelerated irradiation testing and iteration with analytical modeling. The prototypic TFE assembly will eventually be tested in an environment representative of a thermionic reactor.

In mid-FY 1986, a contract was signed to pursue this TFE verification effort. Irradiation testing of insulators and related components was initiated late in FY 1986 and additional insulators, fuels, and emitter components will be placed on test in FFTF in FY 1987. In FY 1988, a second set of TFE component specimens will be inserted in FFTF for accelerated testing and post-irradiation examinations (PIE) will be performed on the first set. A multi-cell TFE assembly will be inserted into a thermal reactor environment, and additional sets of fueled emitters will be inserted into EBR-II and periodically examined for irradiation effects. The design and fabrication of a prototypic TFE assembly will be initiated based on test and PIE results.

DYNAMIC ISOTOPE POWER SYSTEM (DIPS)

The needs of military spacecraft in the planning process include higher power requirements and increased survivability to threats directed at disablement or destruction of the space system. The current standard spacecraft power source, arrays of photovoltaic cells, lacks required features of hardness and has extensive volume that could constrain the maneuverability of these new space systems. One class of spacecraft of current interest for high priority missions requires electrical power in the range of 1 to 10 kilowatts, stringent attitude control and station keeping, and survival from the threats projected for the 1990 time period.

The dynamic isotope power system (an isotope-fueled power subsystem with a combined turbine alternator) is an enabling technology for those military space missions that require survivability against various threats, higher power mission performance, and a small power supply to improve the sensors fields of view of the spacecraft and the overall spacecraft pointing accuracy. In order to make certain that such a highly reliable and efficient isotope powered system in the 1 to 10 kWe range is a viable option for military planners, a joint DOE/DOD demonstration project was initiated in FY 1986 under a supplemental agreement between the two departments. This agreement set up a cost-sharing arrangement, with DOD providing about two-thirds of the funds.

The primary technical objective of the DIPS project is to select, develop and demonstrate the necessary hardware required to provide a dynamic conversion space electrical power system in the range of 1 to 10 kilowatts output for use by emerging military and civilian space missions in the early 1990's and beyond. More specifically, the DIPS project is focused on demonstrating the reliability of a DIPS power system to meet the requirements of the Air Force Boost Surveillance and Tracking System (BSTS) mission. The DOD portion of the DIPS development program is jointly funded by the SDIO and the Air Force. The DIPS flight hardware program will be funded by the Air Force. BSTS is a priority program of the Air Force.

The long-term goal of the DIPS project is to demonstrate that all key technological issues have been addressed successfully through the design, fabrication, and testing of electrically heated Engineering and Qualification units. The major DIPS project goal during 1987 is the selection of the DIPS Subsystem Contractor and completion of the contract negotiation. The target date for contractor selection is July 1987.

In FY 1987, the DIPS contractor will initiate a review and assessment of the Brayton and Organic Rankine conversion cycles, identify critical components and begin their testing, and initiate systems conceptual design studies. The procurement and manufacture of long-lead heat source materials will be implemented in FY 1987 in order to support a safety test program in FY 1988.

Prior to contract startup, conceptual design studies of the heat source/heat exchanger for both the Brayton and Organic Rankine cycles will be pursued by a DOE technical support contractor, in conjunction with the DOE "heat source" laboratories.

During FY 1988, Brayton/Organic Rankine conversion cycle technology assessments and system conceptual design studies will be completed and a cycle/design concept will be selected by DOE. Additional FY 1988 work will include initiation of the DIPS Engineering Unit Design. In FY 1988, the DIPS Engineering Unit Preliminary Design Review is also scheduled for completion and the proposed design approved by DOE. The procurement of long-lead items and materials for the DIPS Engineering Unit manufacture will be initiated. Reliability, survivability and safety studies will be conducted in parallel with the Engineering

Unit design activities and will complement these design activities. A System Safety Program Plan will be developed by the DIPS contractor and approved by DOE. Critical component development, performance, and life testing will be continued.

Pending approval of Supplemental Agreement No. 2 to the DOE/DOD Interagency Agreement, a DIPS Flight hardware project will be implemented so that DIPS flight units will be available on the BSTS schedule. DOE expects to execute this second supplemental agreement later in the current fiscal year.

SMALL NUCLEAR POWER SOURCE DEMONSTRATION PROJECT

There is a need for ground-based power systems that can operate continuously in harsh environments with only occasional attendance and with freedom from the need for frequent replenishment of fuel supplies such as diesel oil. These systems must have high reliability, low maintenance, long lifetimes, and simplified logistics. Nuclear reactor technology appears to offer feasible and improved alternatives to conventional power systems for such applications.

An assessment of a reactor concept of this type was undertaken in FY 1984 for potential application to the North Warning System (NWS). Based on the positive findings of that assessment, SNPSDP conceptual design efforts were initiated in FY 1985. DOE, the Air Force, and Atomic Energy of Canada, Limited (AECL), began to jointly fund a project to investigate and demonstrate the feasibility of using a 15 kWe reactor power source for remote applications such as the NWS. To date, the demonstration reactor fuel, graphite structural components, and reactor control hardware have been procured, and stainless steel heat pipes have been selected for use in the demonstration unit as a result of the heat pipe testing program.

Initially it was planned to test a demonstration reactor at the AECL's Whiteshell facility. In spite of some administrative delays, DOE and AECL plan to continue the project jointly in order to obtain operating data on the demonstration reactor. However, the demonstration will not be tied to the current NWS deployment schedule.

In FY 1987, the final design is being completed, component development testing is continuing, the demonstration reactor mockup is being assembled, and zero power tests on the reactor mockup are being conducted to verify the neutronics performance of the subsystem. The DOE no longer plans to procure the reactor vessel. In FY 1988, in-pile fuel tests will be conducted and, provided the facility is ready, the reactor components will be shipped to Canada and the demonstration unit will be installed in a test cell at the AECL Whiteshell facility. This action will complete DOE program obligations, and DOE does not plan to seek appropriated funds for this project beyond FY 1988. System startup tests are planned to be initiated by AECL in FY 1989.

MULTIMEGAWATT TERRESTRIAL POWERPLANT PROJECT

The Multimegawatt Terrestrial Powerplant (MTP) project is being conducted in response to a requirement identified to us several years ago by the Air Force for a secure and reliable source of electric power. Accordingly, the U.S. nuclear industry was requested to make firm fixed price proposals for a plant that, among other attributes, would have a capacity factor in excess of 90 percent, a refueling interval in excess of 3 years, and a degree of fault tolerance greater than the current generation of commercial nuclear powerplants. Five proposals were received and, in October 1986, one was selected. Upon release of FY 1986 funds from the Air Force, final negotiations and contract execution can proceed.

During FY 1987, the contractor will conduct the preliminary design of the plant, perform initial work on an Environmental Assessment, and begin preparation of a Preliminary Safety Analysis Report.

In accordance with the current Memorandum of Agreement between DOE and the Air Force, the status of the project would be reviewed at the completion of the Preliminary Design and, if the results are favorable, DOE and the Air Force would enter into the detailed design phase in FY 1988, which will last until about June 1989. The Air Force will then decide where, and if, to construct the first plant.

If the Air Force should decide not to proceed with this project beyond preliminary design due to a change in their requirements or due to funding limitations, DOE would then apply the $6.5 million requested for MTP in FY 1988 to other Space and Defense Power Systems program activities. This funding would enhance or enable the accomplishment of a particular milestone, such as maintaining schedule and avoiding cost overrun, or expediting the delivery of hardware. Specifically, we would reallocate the $6.5 million requested in FY 1988 for MTP as follows:

- $2.0 million for purchasing iridium cladding material for DIPS heat sources, thereby expediting fabrication and avoiding a 1-year delay in availability.

- $3.5 million for nuclear power system design and irradiation testing efforts in the SP-100 GES program to enhance the flexibility of the system to respond to mission-specific requirements, e.g., increased or lower power levels (from the 100 kWe reference power level), radiator configurations other than conical, etc. This increase would also allow DOE to more fully meet commitments contained in its Memorandum of Understanding (MOU) with the Air Force, thereby mitigating any schedule delays resulting from that shortfall.

- $1.0 million for initiating the design of irradiation experiments for advanced high temperature materials and cermet fuels for the multimegawatt space reactor, thereby expediting these tests by up to 1 year.

ADVANCED NUCLEAR SYSTEMS

The Advanced Nuclear Systems program develops, demonstrates, and delivers radioisotope power sources for U.S. military and civilian space and terrestrial missions. Included in the program are the base level support for fuel production and testing, nuclear safety analysis and testing, quality assurance, reliability and operational safety for DOD/SDIO/NASA missions that use, or will use, isotope power systems. DOE plans to continue to maintain a viable heat source production capability within its laboratory structure in order to support future RTG deliveries. This laboratory structure provides a national capability to support DIPS, special applications RTGs, and future NASA missions. In 1987, DOE is maintaining and upgrading heat source production and RTG fueling capabilities.

Current programs supported under the ANS decision unit include the NASA Galileo and Ulysses missions, DOD Special Terrestrial Applications, and flight systems support to the DIPS program for Air Force and SDI applications. All of these projects are jointly funded with DOD or civilian agencies. Future missions on which isotope power systems are planned for use are Mariner Mark II (a series of NASA interplanetary missions in the early 1990's) and a DOD Special Terrestrial Applications project in the mid-1990's.

A major effort during past years under the RTG portion of the ANS program has been the design, fabrication, and delivery of the General Purpose Heat Source (GPHS) RTGs, preparation of safety analysis reports, and delivery of radioisotope heater units for the NASA Galileo and Ulysses missions. The delay in the first launch to 1989 added appreciably to the remaining pre-launch activities, particularly in the safety and the RTG testing areas. Since the January 1986 Challenger accident, DOE has been working closely with NASA to prepare a new Final Safety Analysis Report (FSAR) for the current launch dates. The cancellation of the

Shuttle/Centaur has significantly changed many safety issues since the Centaur was the main contributor to the risk as calculated in the FSAR. However, the preliminary analysis of the Challenger and Titan 34D accidents has shown a need to focus on determining the RTG response to being hit by a piece of the casing from the solid rocket motors. While preliminary analyses indicate this may not be a problem, confirmatory tests must be run in 1987 and 1988 to support a 1989 launch. In addition, the new trajectory for Galileo involves two passes by Earth. This requires an analysis of the response of the RTG to an accidental reentry occurring as a result of one of these flybys.

New tests and an extensive set of new analyses--in some cases, using new models--will be required to incorporate the findings from the Challenger and Titan 34D accidents. Thus, full funding of the safety and technical support organizations as well as the system contract efforts is essential if DOE is to complete the first FSAR in 1988, to support a 1989 launch, and the second FSAR in 1989, to support a 1990 launch.

In addition, there are numerous activities keyed to work on both the Galileo and Ulysses missions as well as the terrestrial RTG program. For example, DOE is protectively storing and monitoring the four flight RTGs for Galileo and Ulysses. DOE is also conducting long-term performance tests ("life tests") on a Qualification Unit and Engineering Unit to confirm reliability and power predictions for the Galileo and Ulysses missions. The launch delay, coupled with the new upper stage for Ulysses, will change the internal load on the RTG that holds the heat source modules in place. This is a major operation almost akin to disassembly, reassembly, and acceptance testing on two RTGs. This work will have to be completed in 1988 to support a 1989 launch option for the Ulysses mission. This requires a major resource commitment to the DOE Mound Plant in Miamisburg, Ohio.

In looking to the future, DOE is continuing to pursue the technology and the development of an advanced RTG that offers the promise of higher power density and greater size adaptability for the next generation of DOD and NASA missions, such as the Mariner Mark II. The modular concept to be employed on the generator will enable NASA to accommodate a range of interplanetary missions. During 1988, thermoelectric modules will be produced and assembled into a ground engineering system for demonstration tests.

In parallel with the advanced modular RTG development, DOE is continuing its efforts to improve thermoelectric conversion efficiencies, including silicon germanium optimization, electrical contacting, evaluation of materials properties, degradation mechanisms, and material interactions.

In 1988, several laboratories working on heat source efforts will start production activities for the DIPS flight program. DOE will also continue those efforts necessary to improve heat source safety, improve production efficiency to reduce heat source costs, and continue work in long-lead areas. Included is the redesign and design verification of changes to the GPHS-RTG to improve safety and performance for future missions.

To meet DOE obligations to deliver RTGs for terrestrial military missions, the Special Applications program will continue its efforts to develop and demonstrate the necessary technology. During 1987, an engineering demonstration unit was placed on extended life testing, and testing of thermoelectric modules continued. DOE is also delivering three 5 Watt (electrical) RTGs in 1987 to DOD under a reimbursable agreement. During 1988, DOE will continue design and integration studies for specific missions, continue testing of the engineering unit and thermoelectric modules to develop reliability data, and complete facility and tooling modifications at the Mound Plant for the

fueling, assembly, testing, and delivery of a 180 watt (electrical) RTG late in the fiscal year. DOE will also continue the safety qualification of a small, sealed, terrestrial heat source to meet projected DOD requirements for small RTGs in the early and mid 1990's.

FACILITIES

The Department operates some of the most advanced and sophisticated test facilities in the world for development of advanced power generation reactors, fuels, components, and materials. The facilities provide unique testing capabilities which are not available in the private sector (or, in some cases, anywhere in the world) and which are required for the development of safe, reliable, environmentally acceptable and efficient nuclear energy power sources for civilian power generation, space, and defense energy applications. These facilities are used for conducting prototypic testing for future civilian and space liquid metal-cooled reactor systems; they are also used in the development of materials for fusion technology, in cooperative technology programs with other countries, and for conducting tests for other Government and private sector organizations (such as EPRI and the NRC). The capital cost of these facilities precludes their being duplicated by the private sector; thus, their continued availability and productivity depends on DOE.

The facilities include the following LMR facilities: (1) the EBR-II, the Transient Reactor Test (TREAT) facility, the Zero Power Plutonium Reactor (ZPPR), the Hot Fuel Examination Facility (HFEF-S), and support facilities at Argonne National Laboratory near Idaho Falls, Idaho (ANL-West); (2) the FFTF and supporting facilities at HEDL near Richland, Washington; and (3) the comprehensive non-nuclear liquid metal component test complex at the Energy Technology Engineering Center (ETEC) near Canoga Park, California. A critical element of each facility's capabilities

are its experienced engineers, scientists, technicians, and operators.

In recent years, the program has markedly improved the efficiency of its facility operations. Non-essential facilities have been shut down and operational efficiency of remaining facilities has been improved. At ETEC, a revenue-producing power addition is under construction. A study is also underway to address the feasibility, design, power marketing, and other aspects of a privately-financed power addition to the FFTF. By FY 1988, annual ANL-W, HEDL, and ETEC facilities budget and manpower levels will have been halved from FY 1981 levels. The majority of these reductions have already been accomplished.

The planned FY 1988 program includes test programs in reactor safety and fuel performance in the EBR-II, FFTF and TREAT reactors; component testing for advanced LMR concepts (e.g., helical coil steam generator testing at ETEC); irradiation of candidate core materials for space reactor use; fabrication of U-Zr fuel pins at ANL-W for FFTF; irradiation of the Space and Defense programs SP-100 fuel and cladding; run-beyond-cladding breach operational transient testing under the joint United States/Japan Cooperative Program; irradiation of material specimens for the joint United States and Japan fusion program; modification of HFEF-South for development and verification of advanced metal fuel reprocessing, fabrication and waste treatment technologies; critical experiments in ZPPR for SP-100 and for large oxide core joint tests with the Japanese; and tests in various facilities supporting advanced reactor plant simplifications and cost reduction features.

In FY 1987, HEDL will discontinue work on the Secure Automated Fabrication (SAF) line, which was developed and built to produce enriched uranium-plutonium oxide fuel for the FFTF. As highlighted in our FY 1988 budget request, metal fuel is the reference fuel cycle for the current modular LMR design effort. Accordingly, FFTF operations will begin a transition to a metal fuel core to obtain additional metal fuel irradiation data. In FY 1988, prior to completion of cold checkout, certain portions of the SAF line will be placed in a standby condition. The DOE Office of Defense Programs will assume responsibility for the Fuels and Materials Examination Facility, including the SAF line, beginning in FY 1988. Use of the FMEF will be shared between the DOE Offices of Nuclear Energy and Defense Programs.

The Department continues to stress that non-program users must share in facility operating costs. Cost-sharing approaches are being partially implemented in FY 1987 with full implementation planned for FY 1988.

REMEDIAL ACTION AND WASTE TECHNOLOGY

The objectives of the Remedial Action and Waste Technology Program are to stabilize radioactive wastes or perform decontamination and decommissioning at contaminated DOE and legislatively-authorized non-government facilities and sites; facilitate development of a reliable national system for managing low-level radioactive wastes; and develop beneficial uses of nuclear waste byproducts. Successful execution of this program is a key part of the Department's commitment to continue to protect public health and safety and to assure a safe and clean environment in connection with its activities.

The major Remedial Action and Waste Technology activities are: (1) the Formerly Utilized Sites Remedial Action Project (FUSRAP), remedial action at sites formerly utilized by the Department's predecessor organizations or assigned by Congress; (2) remedial action at Grand Junction, Colorado (Public Law 92-314, as amended); (3) the Uranium Mill Tailings Remedial Action Project (UMTRAP) for inactive uranium mill tailing sites and several thousand associated vicinity properties (Public Law 95-604); (4) the Surplus Facilities Management Program (SFMP), for certain radioactively contaminated DOE facilities declared surplus and resulting principally from civilian nuclear energy programs; (5) the West Valley Demonstration Project, which will solidify high-level radioactive wastes at West Valley, New York, for final disposal (Public Law 96-368); (6) the Low-Level Radioactive Waste Management Program, which, among other things, provides technical assistance to States and regions to assist them in developing new capacities for the disposal of low-level radioactive waste, in accordance with Public Law 99-240, the Low-Level Radioactive Waste Policy Amendments Act of 1985; and, (7) the Civilian Byproducts Utilization Program which will be transferred to the private sector in FY 1988.

The requested funds for the Remedial Action and Waste Technology Program are distributed among the program elements as indicated in the following table.

	----($ in Millions)----	
Program Element	FY 1987 Appropriation	FY 1988 Request
Remedial Action and Waste Technology		
Formerly Utilized Sites	$ 25.6	$ 23.0
Grand Junction	0.8	0
Uranium Mill Tailings	116.0	116.0
Surplus Facilities	44.4	51.0
West Valley	79.0	54.2
Low-Level Waste	4.0	5.0
Byproducts Utilization	5.0	0
Program Direction	2.1	2.3
Total	$ 276.9	$ 251.5

FORMERLY UTILIZED SITES REMEDIAL ACTION PROJECT

The Department's Oak Ridge Operations Office has the lead field management responsibility for implementing the Formerly Utilized Sites Remedial Action Project. FUSRAP provides for remedial actions at former nuclear processing facilities which became radioactively contaminated as a result of former Manhattan Engineer District or Atomic Energy Commission (MED/AEC) activities and which have not been decontaminated sufficiently to meet current public health and safety guidelines. FUSRAP also includes certain contaminated sites specifically assigned to DOE by Congress for remedial action.

To remedy the situation at these contaminated sites, either the contaminated material will be stabilized in place, with restrictions placed on the use of the site, or the contamination will be removed and disposed of at another location. Authority currently exists, derived from the Atomic Energy Act of 1954, for conducting remedial actions based on a review of the involvement of the Department's predecessor agencies in activities at these sites. In 1985, this review process led to DOE adding the following four sites to the project: (1) the former Bridgeport Brass Company site in Adrian, Michigan, now a General Motors property; (2) the former Bridgeport Brass Company site in Seymour, Connecticut, now owned by Seymour Wire Specialty; (3) the Chicago, Illinois, National Guard Armory; and (4) the former Metal Hydrides, Incorporated, site in Beverly, Massachusetts, now owned by the Ventron Division of Thiokol Chemical. Review of other sites involved in past activities of the Department's predecessor organizations is continuing and is scheduled to be completed this year. This review may result in the addition of other sites to the program.

Congress added four sites to the program when it enacted Public Law 98-50, the FY 1984 Energy and Water Development Appropriations Act, and directed that DOE initiate a decontamination R&D project at these sites as a priority action. Subsequent enactment of Public Law 98-360, the FY 1985 Energy and Water Development Appropriations Act, Congress directed DOE to acquire the former St. Louis Airport site and use it to dispose of waste from the cleanup of the nearby Latty Avenue site and vicinity properties. Congressional and Departmental additions bring the total number of sites in the program to 29.

In FY 1986, the Department completed cleanup work at the contaminated properties near the DOE Niagara Falls Storage Site at Lewiston, New York. Work was also completed on the installation of an interim cap on the waste storage area. Other remedial actions at this site are described under the Surplus Facilities Management Program section.

The Department completed the remedial actions at the Middlesex Landfill in New Jersey in FY 1986. This completes the Department's remedial action efforts in Middlesex until such time as a disposal site is identified for the waste material currently stored at the Middlesex Sampling Plant as well as for the waste that will be generated during cleanup of the Middlesex Sampling Plant site.

Decontamination actions at Maywood, New Jersey; Wayne, New Jersey; and Colonie, New York, continued in FY 1986. The general approach to these projects is to give priority to the cleanup of contaminated residential properties and to store the waste temporarily on each processing and storage site. The cleanup of residential properties in Maywood, contaminated with material from the Stepan Company site, was completed in FY 1985, along with some residential properties found to be contaminated from the Stepan site in the adjacent town of Lodi. The contamination from the Stepan site has been found to be more extensive, extending into Lodi and under New Jersey Route 17. In FY 1986, cleanup of one Maywood commercial property continued. Extensive characterization of the contaminated areas and engineering for further remedial actions will be completed. The waste from this site is being stored on an 11.7 acre portion of the Stepan Company property at Maywood, which Stepan donated to DOE in 1985 along with $580,000. The storage pile was expanded in 1985 and modified to meet State requirements.

At Wayne, New Jersey, about one-third of the cleanup of Sheffield Brook and cleanup of residential properties bordering the brook was completed in FY 1986. In FY 1987, cleanup of the remaining portion of Sheffield Brook will be completed. In FY 1986, modifications to the site were completed so that wastes can be stored on the site temporarily. The site is considered unsuitable for permanent stabilization because of ground water flow. The State of New Jersey has been requested to nominate candidate locations in the State for DOE to establish a site for disposal of the estimated 50,000 cubic yards of waste at Wayne, as well as the other estimated 360,000 cubic yards of FUSRAP waste at Middlesex and Maywood.

At Colonie, New York, DOE acquired the National Lead Industries site as a donation in February 1984, along with two adjacent parcels owned by the Niagara Mohawk Power Company that have waste buried on them. Radiological surveys of a total of 211 vicinity properties have been completed through FY 1986, and to date, 44 of these properties have been determined to need remedial action. About 20 to 30 additional properties remain to be surveyed in FY 1987. Cleanup of 35 properties was completed by October 1985 (11 in FY 1984 and 24 in FY 1985) and all remaining properties will be completed by October 1988. This work was delayed one year until FY 1988 to allow for the completion of more high priority work. The contaminated soil is being temporarily stored inside the plant. In FY 1986, DOE completed a study of options for the permanent disposition of the more than 30,000 cubic yards of waste and disposed of radioisotope sources previously used for inspection work and of some of the hazardous chemicals in the plant. In FY 1987, DOE is initiating site characterization and chemical stabilization of areas defined in FY 1986. In FY 1988, DOE will complete remedial actions on vicinity properties.

At Hazelwood, Missouri, DOE has arranged with the site owner, Futura Chemicals Company, to use a part of the site for the storage of contaminated soil. Border areas on the site were cleaned up to prevent recontamination of Latty Avenue, and fencing was installed around the site. Radiological surveys of the vicinity properties are being performed in FY 1987, and a survey of the developed part of the Latty Avenue site was started in FY 1987. This was about 6 months later than originally planned because of difficulties in obtaining access from the owner. Design engineering work for remedial actions will begin in FY 1988. Cleanup activities on the remaining properties will not be started until the waste can be moved to the former St. Louis Airport site if the site is found to be suitable. The City of St. Louis, Missouri, is considering the terms of transfer of the former St. Louis Airport Storage site. The Department is presently determining if the St. Louis Airport site is adequate to dispose of the waste from the Hazelwood site, vicinity properties, and the site itself. DOE will seek further Congressional direction if the site is not adequate. If the site is suitable, DOE will begin design engineering and NEPA documentation during FY 1988.

At the National Guard Armory in Chicago, Illinois, characterization efforts are under way to define the extent of contamination on the site. It is expected that cleanup of this site will both begin and be completed in FY 1987 with the relatively small quantity (50 cubic yards) of waste being disposed of at DOE's Hanford Reservation.

A revision to the FUSRAP Project Plan was prepared in FY 1986 and submitted for approval. A preliminary total cost estimate of $740 million has been made for the FUSRAP scope, consisting of 29 sites, based on completion of all the work by the year 2001. The Plan will be updated again in FY 1987.

GRAND JUNCTION REMEDIAL ACTION PROJECT

Under Title II of Public Law 92-314, Congress authorized financial assistance to the State of Colorado to limit radiation exposure resulting from the use of uranium mill tailings for construction purposes in Grand Junction, Colorado. This State and Federal cooperative effort is administered by the Colorado Department of Health through DOE's Grand Junction Project Office. The remedial action provides for removal of uranium mill tailings from the premises of approximately 600 structures where concentrations of radioactive radon and its decay products exceed guidelines established by the Surgeon General. Public Law 95-236 extended the time, which has now expired, for property owners to apply for inclusion and also increased the authorized funding for the program. Federal funds cover 75 percent of the program costs, with the State providing the balance. Contingent upon the availability of adequate funding from the State of Colorado, the remedial action is expected to be completed in FY 1987, with final radiological verification to be completed in FY 1988.

At the end of FY 1986, work had been undertaken on 577 structures and engineering on all properties had been completed. In FY 1987, radiological assessments will be continued and remedial actions will be initiated at all remaining structures. In FY 1988 the project will be closed out by certifying all vicinity property remedial action completions.

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT

Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978, assigned to DOE the responsibility for conducting remedial action at 24 former uranium ore processing sites and several thousand contaminated vicinity properties. Nine of the sites are designated as high priority, six as medium priority, and nine as low priority. The Act provides authority for remedial action by the Department for a period of 7 years following promulgation of standards by the Environmental Protection Agency (EPA), which occurred in March 1983.

The Department is proposing to extend the 7-year authorization period until the end of FY 1993, consistent with the recommendation to extend the duration of the project made by the House Committee on Appropriations in House Report No. 99-195. The FY 1988 budget request identifies resource requirements to meet this extended schedule. The proposed extension takes into consideration the actual project experience gained in performing remedial action at several processing sites and many vicinity properties. Project plans have been revised to reflect this experience, and are based on the following key assumptions: (1) 4,800 of the 8,156 designated vicinity properties will actually require cleanup in accordance with EPA standards; and (2) eight of the tailings piles (located in or near Durango, Grand Junction, Gunnison, Rifle, and Naturita, Colorado; Belfield, North Dakota; Lakeview, Oregon; and Salt Lake City, Utah) will be relocated.

The program strategy is to focus near-term program activities on the higher priority sites and on vicinity properties. Remedial actions are being conducted in accordance with cooperative agreements negotiated with the affected States and Indian tribes. Federal funds cover 90 percent of the remedial action costs (100 percent for the sites on Indian lands), and the States provide funding for the remaining 10 percent. The type of remedial action for the processing sites will be to stabilize the mill tailings in place, where possible, or to remove them to a new disposal site. In either case, the final disposal sites will be Federally owned and maintained under NRC license. Engineering plans and environmental documents are prepared for each site cleanup and disposal operation. Concurrence by the NRC and the affected State or Indian tribe is required for the remedial action plan at each site. The project also involves the cleanup of an estimated 4,800 contaminated vicinity properties mainly in the Grand Junction, Colorado, area but not covered by the Grand Junction Remedial Action Project. The Department's Albuquerque (New Mexico) Operations Office has the field management responsibility for implementing UMTRAP.

Specific accomplishments in FY 1986 included the completion of 100 percent of the remedial action at Canonsburg, Pennsylvania; completion of 85 percent of remedial action at Salt Lake City, Utah; and 95 percent completion at Shiprock, New Mexico. Construction management of the remedial action at the Salt Lake City processing site is being carried out by the State of Utah. The approach at this site is to relocate the tailings to a site near Clive, Utah. Remedial action was initiated in FY 1986 at the Lakeview, Oregon, site. Cleanup continued at high-priority vicinity properties near the sites at Canonsburg, Pennsylvania; Durango, Colorado; Salt Lake City, Utah; Grand Junction, Colorado; Edgemont, South Dakota; and Shiprock, New Mexico. Remedial action was completed on nearly 400 vicinity properties during FY 1986.

During FY 1987, work is underway or planned at eight processing sites. The work at Salt Lake City, Utah, and Shiprock, New Mexico, will be completed. Onsite work will continue at Tuba City, Arizona, and Lakeview, Oregon. Processing site remedial action will begin at Ambrosia Lake, New Mexico; Durango and Grand Junction, Colorado; and Riverton, Wyoming. Remedial action on over 800 vicinity properties will also be completed.

During FY 1988, remedial action will be underway at 7 processing sites and 1,000 vicinity properties. Remedial action will be completed at the Lakeview, Oregon, site. Site remedial action will be continuing at Durango, and Grand Junction, Colorado; Riverton, Wyoming; and Tuba City, Arizona. Remedial action will be initiated at the Gunnison, Colorado, and Green River, Utah, sites. Surveillance and maintenance activities will be conducted at completed sites (Canonsburg, Pennsylvania; Lakeview, Oregon; Salt Lake City, Utah; and Shiprock, New Mexico).

SURPLUS FACILITIES MANAGEMENT PROGRAM

This program provides for the safe management and disposition of certain surplus radioactively contaminated DOE facilities from civilian nuclear energy development activities. The decontaminated facilities and sites are to be returned to other productive use, where appropriate. The facilities are grouped into 32 projects under this activity. This number increased by one in FY 1987 because the Department assumed responsibility for decommissioning the Power Burst Facility (PBF) in Idaho, formerly supported by the NRC. A long-range plan was completed in April 1985 to establish the overall schedule and priorities for sites currently in the surplus inventory. Revisions to this plan are made as necessary resulting from revised program budget guidance. Priorities are established and work schedules are developed within available funding through analysis of public health and safety, legal, economic, and work continuity factors for each site. Although program management of the SFMP was transferred from the Department's Richland (Washington) Operations Office to DOE Headquarters during FY 1987, work on individual projects is carried out by various DOE field offices as assigned.

In FY 1986, the interim storage cell was completed at the NFSS. A thick clay cap with a design life of greater than 25 years was placed over the wastes to minimize water infiltration and radon emission. A Final Environmental Impact Statement (EIS) and Record of Decision on the long-term management for the site were issued in FY 1986. DOE is completing water treatment and contractor demobilization in FY 1987. In FY 1988, only surveillance and maintenance of the NFSS is planned.

Work on the decontamination of plutonium-contaminated facilities at Mound Laboratories in Miamisburg, Ohio, is behind schedule due to identification of additional quantities of contamination and will be continued in FY 1987 and FY 1988. This project was begun in 1978 and will now be completed in FY 1990.

Decommissioning of the Shippingport Atomic Power Station is designated a major DOE project. Following defueling of the reactor at the end of FY 1984, physical dismantling of the plant began in September 1985. Dismantling of portions of the plant continued in 1986 and will continue in 1987. The project is scheduled to be completed in early FY 1990. Preparation for the removal of the reactor pressure vessel will begin in FY 1987; the vessel is scheduled to be barged to the Department's Hanford Reservation near Richland, Washington, for disposal as low-level waste in FY 1989. The Department is cooperating with the NRC and EPRI in obtaining samples of the pressure vessel for aging studies. Other components will also be examined for this purpose. The Department is also participating in an international exchange of decommissioning technology sponsored by the NEA. The NEA program includes the Shippingport decommissioning and West Valley demonstration projects in the United States, as well as eight significant decommissioning projects in other NEA-member countries.

In FY 1986, the Department awarded the project management contract for the Weldon Spring Site Remedial Action Project in Missouri, another major DOE project, and established an onsite project office. Field work for the characterization (radiological, chemical, and geological) of the Chemical Plant area is continuing. A draft EIS was issued in February 1987, later than originally planned to incorporate additional characterization work and EPA comments on the preliminary draft. The Weldon Spring Quarry will be added to the Superfund National Priorities List by the EPA in 1987. The Department's preferred alternative is stabilization of the wastes onsite in a disposal cell. Conceptual design engineering by the project management contractor began in FY 1986 and continues through FY 1988. The Final EIS and Record of Decision will be issued in FY 1988. Contractors will be mobilized on the site, and remedial action will be started on the quarry in FY 1988, which is later than originally planned. We estimate that remedial actions at the Weldon Spring site will be completed in FY 1995 and a final report issued by the end of FY 1996.

As previously mentioned, a new project was added to the SFMP in FY 1987--the decommissioning of the Power Burst Facility in Idaho. Consequently, only surveillance and maintenance was conducted in FY 1987. Unless alternative uses are found for the PBF, DOE plans to place the facility into an interim safe storage condition by initiating stabilization and fuel removal in FY 1988. The facility is expected to be in a safe storage condition by the fourth quarter of FY 1990. This condition will minimize surveillance and maintenance costs until funds are available for complete decommissioning.

Other activities in FY 1987 will include continuation of site and facility disposition projects at Monticello, Utah; Santa Susana, California; the Oak Ridge National Laboratory in Tennessee; and the Idaho National Engineering Laboratory in Idaho. Decommissioning of the research reactor at the Center for Energy and Environment Research (CEER) in Puerto Rico will begin in FY 1987. At Monticello, Utah, mill tailings will be removed from 7 additional residential properties, leaving about 12 properties to be completed in FY 1988 and FY 1989. The environmental assessment will be completed for the Monticello mill site in FY 1987 and work on the site is planned to start in FY 1988. Due to funding reductions in FY 1987, ongoing activities at the Argonne National Laboratory in Illinois and the Los Alamos National Laboratory in New Mexico were stopped and deferred indefinitely.

WEST VALLEY DEMONSTRATION PROJECT

The objective of the West Valley Demonstration Project is to demonstrate the solidification process for disposal of high-level liquid nuclear wastes under the provisions of Public Law 96-368, the West Valley Demonstration Project Act. An integrated production-scale development and demonstration project for treating high-level liquid nuclear wastes is being carried out at the Western New York Nuclear Service Center, near West Valley, New York.

Major activities being performed as part of this project include: (1) decontamination required to prepare existing facilities and equipment to accommodate the solidification project; (2) removal of wastes from underground storage tanks; (3) development, design, construction, and operation of systems and necessary supporting facilities for the solidification of the wastes; (4) acquisition of containers for the permanent disposal of the solidified waste; (5) temporary storage and transportation of the solidified waste to an appropriate Federal repository for permanent disposal; (6) decontamination and decommissioning of the waste tanks, facilities, hardware, and material used in carrying out the project; and (7) disposal of low-level and transuranic wastes produced from project activities.

In FY 1986, final design was completed for the Supernatant Treatment System, which will be used to pretreat and reduce the volume of the liquid high-level waste. Major construction of this system was ongoing, procurements were received, and preparations for final installation were initiated. Installation of equipment for treating low-level liquid wastes before they are solidified in cement continued. Decontamination of cells needed for installation of the radioactive waste treatment system was completed.

In FY 1987, the Supernatant Treatment System will be completed, the equipment will be tested, and nonradioactive integrated testing will begin. The nonradioactive testing program will include comprehensive testing of other systems with which it will interface. Processing of the radioactive supernatant is planned to start late in the fiscal year. The supernate now stored in underground tanks represents nearly 90 percent of the volume and 50 percent of the radioactivity of the stored liquid waste. The separated radioactive material will be stored and later blended with the sludge from the storage tanks and glass formers prior to being fed into the melter in the Vitrification Facility. The low-level waste resulting from operation of the Supernatant Treatment System will be treated in the Liquid Waste Treatment System and the Cement Solidification System. Decontamination of needed shielded rooms will continue.

The processing of the supernate, to begin in late 1987, will continue through the year and be completed late in FY 1988. The resulting low-level waste will continue to be processed. The processing of the sludge in the stored waste will begin when the supernate processing is completed. Nonradioactive testing of the Vitrification Facility will continue in FY 1988 in parallel with modifications and construction necessary to convert it for eventual radioactive operation.

West Valley funding reductions in FY 1986 through FY 1988 have resulted in a postponement of the planned start of high-level waste vitrification by approximately 1 year. The current target date for this activity is the fall of 1989.

LOW-LEVEL WASTE PROGRAM

The Low-Level Waste Program provides technical assistance to States and regions in developing new capacity for the disposal of low-level radioactive waste in accordance with Public Law 99-240, the Low-Level Radioactive Waste Policy Amendments Act of 1985.

This legislation assigned individual States the responsibility for the disposal of low-level radioactive waste generated within their borders, with the exception of such waste generated as a result of certain Federal activities and non-DOE generated low-level waste exceeding the limits established by the NRC for Class C low-level waste. The formation of regional compacts among States to carry out their responsibilities is encouraged by the Act. Towards that end, DOE administers an escrow account created by the Act, from which payments are made to States in compliance with the Act's milestones. DOE created criteria for compliance and determined each State's compliance status for the first milestone, and is developing criteria for the next milestone, which occurs on January 1, 1988.

The goal of the Department's Low-Level Waste Program is to assist States and regions in meeting their responsibilities in the development of an effective nationwide low-level waste management system according to the provisions and milestones established by the Act. The Act has also assigned several new responsibilities to the Department in addition to providing assistance to States and compact regions.

During FY 1987, the Low-Level Waste Program will conduct the various reporting and administrative activities required in the Act and will focus on meeting the generic technical needs of the States and compact regions as they work to select sites and develop new disposal facilities. Specifically, the Department plans to concentrate on assisting States and regions in evaluating alternative disposal technologies to those currently in practice at the currently operating sites in Washington, South Carolina, and Nevada. An evaluative study and workshop on known characteristics of potential alternative disposal technologies are planned as well as a project to submit a design report or two such alternatives to the NRC for a licensing review. The program will also continue to monitor the development of innovative waste treatment methods in the private sector. The Department has submitted a report to Congress continuing recommendations leading to the disposal of greater-than-Class C low-level waste and will continue to carry out responsibilities assigned to it under the Act. Reports on State and compact regional progress and the use of escrow account rebate funds will be submitted to Congress in FY 1987, as required by the Act.

In FY 1988, the Low-Level Waste Program will continue to provide technical assistance to States and regions to support the selection and development of new low-level disposal facilities. It will follow the correction of problems and stabilization at existing disposal sites and assess innovative methods for the treatment and disposal of low-level waste. In FY 1988, planning for implementing the Department's recommendations to Congress on low-level wastes exceeding Class C limitations will be conducted, and the Department will continue to carry out its administrative and reporting requirements to Congress, as required by the Act.

BYPRODUCTS UTILIZATION

In FY 1986, Congress directed DOE to initiate a civilian byproducts utilization program that emphasized food irradiation applications. The goal of this program is to develop and transfer the technology for the beneficial use of nuclear byproducts. Irradiation of food and other agricultural commodities will be emphasized in cooperation with States and other Federal agencies.

DOE is proceeding with plans to support regionally-based commodity irradiation facilities in six States--Oklahoma, Hawaii, Iowa, Florida, Washington, and Alaska. The basis for selecting these States are their proximity to major agricultural commodity production and processing centers and the benefits to be derived by their use of food irradiation processing. The DOE program will also focus on developing an adequate U.S.-based supply of irradiation sources for commodity irradiations.

In FY 1987, cooperative agreements will be negotiated with designated project sponsors in the six States. Plans for the irradiator facilities will also be developed to demonstrate that irradiation of agricultural commodities can be a beneficial and unique method of processing and preserving food groups. The project sponsors will be responsible for developing an integrated regional plan that includes (in addition to DOE) the involvement of such organizations as regional universities, agricultural research groups, regulatory agencies, suppliers of agricultural commodities, food processors, and market testing groups. Cooperative funding of these projects is planned. The Department will assist the project sponsors in obtaining from States and the private sector sufficient resources that may be required to cost-share the development of the six regional facilities.

WASTE TREATMENT

In FY 1987, DOE will complete a collaborative program with the Federal Republic of Germany to produce 30 heat and radiation sources for testing purposes in the West German radioactive waste repository program. The civilian waste treatment research and development program at the Pacific Northwest Laboratory will be phased out, the radioactive waste vitrification system placed in a standby condition, and documentation of research and development findings to date completed. No funds are requested for this program in FY 1988.

URANIUM SUPPLY AND ENRICHMENT ACTIVITIES

The funds requested in FY 1988 for this major activity are distributed among the following elements:

Program Element	FY 1987 Appropriation	FY 1988 Request
	----($ in Millions)----	
Uranium Enrichment Activities		
Gaseous Diffusion Operations & Support	$1,017.6	$1,064.5
Atomic Vapor Laser Isotope Separation	80.0	0
Gas Centrifuge	4.0	0
Program Direction	4.8	5.5
Subtotal	1,106.4	1,070.0
Reserve	104.0	0
Total	1,210.4	1,070.0
Uranium Enrichment Revenues	-1,286.4	-1,301.0
Net Appropriation	-76.0	-231.0

As Congress has consistently recognized, energy security and national security provide strong motivation for maintaining an efficient, stable, competitive uranium enrichment capability in the United States. Domestic employment and energy security are bolstered by a secure, reliable, and economical supply of enriched uranium, free of the threat of foreign supply disruptions or price controls. Foreign commercial sales aid in the Nation's balance of trade payments and contribute to the Nation's nuclear nonproliferation efforts through our involvement in the nuclear fuel cycle. Finally, important national security objectives are supported by the availability of a safe, dependable supply of highly enriched uranium at reasonable costs for U.S. defense programs. Resolution of several significant issues that currently face the uranium enrichment enterprise is essential to assure its long-term competitiveness.

The state of the Uranium Enrichment business today is in marked contrast to the situation that existed only a few short years ago. In the early 1980's, the Department faced mounting problems as it attempted to operate in the increasingly competitive world uranium enrichment market. Previously, the U.S. had enjoyed a monopoly position in the free world as the sole provider of enrichment services. However, by the early 1980's, fierce competition from foreign suppliers of enrichment services, and an active spot market created by large customer held inventories were seriously eroding our sales base. To make matters worse, relatively high operating, power demand, research, and construction costs and the strength of the U.S. dollar combined to make DOE the world's highest priced supplier of enrichment services.

As a result, DOE's world market share decreased from 100 percent in 1974 to 46 percent by 1985 as DOE customers terminated contracts, in whole or in part, with a sales value of about $5 billion.

To combat this situation, DOE established a major initiative in early 1984 to restore the competitive position of the United States in the world enrichment market. The objectives of this three-part strategy were, first, to stem the loss of sales and save the business; second, to adjust the various elements of the business to adapt to the competitive marketplace; and, finally, to assure the long-term health of uranium enrichment in the United States by revamping its strategy and possibly its organizational structure.

The Department's three-part initiative has revitalized the uranium enrichment program. Within this context, there are several actions that the Department plans to take in the future to solidify its position as a world leader in the global uranium enrichment market. DOE's recovery strategy is based on proven methods used by the private sector and has drastically improved our competitive position in just 3 years. The major elements of our strategy were:

- Reestablish a stable market via the Utility Services contracts and aggressive marketing initiatives;
- Develop minimum cost approaches to meeting customer demand; and,
- Restructure the enterprise as required to assure long-term stability and competitiveness.

REESTABLISH A STABLE MARKET

The first objective was to reestablish a stable market and bring supply and demand of DOE-origin enriched uranium into balance. This was accomplished in January 1984, when the Department offered the Utility Services (US) contracts. About 90 percent of the DOE customers converted to these contracts, which established a stable planning base for DOE while allowing DOE customers to reduce their existing inventories.

Once the sales base stabilized, the next step was to undertake a number of aggressive marketing initiatives. In April 1985, DOE offered an incentive price of $90 per separative work unit (SWU) to attract uncommitted sales in the 1987-1990 timeframe. This offer proved successful, with 87 percent of DOE customers accepting this proposal. As a result, DOE's sales increased by about 5.6 million SWU's, with additional revenues of over $500 million through 1990.

In 1986, the Department completed another highly successful marketing initiative, known as Incentive Price II. In return for customer commitments to purchase 100 percent of their enrichment requirements from DOE during the period 1991 to 1995, the Department offered a price of $85 per SWU for the top 30 percent of their enrichment requirements. Over 75 percent of the customers accepted this proposal, resulting in additional sales of 13.7 million SWU's, with additional revenues of about $1.2 billion through 1995.

With the success of the US contracts and marketing initiatives, DOE's world market share has stabilized after 10 years of steadily declining sales. In fact, our free world market share will increase from 46 percent in 1986 to 50 percent in 1987 and to 53 percent in 1990. This increase in market share is particularly significant when viewed in the context that the size of the free world market is increasing between 1986 and 1990 by approximately 25 percent.

The DOE must maintain constant vigilance of competitive offers available to customers from foreign enrichment suppliers. Three specific areas are being monitored very closely. First, it is well known that the Soviet Union has excess capacity of several million SWU per year that can compete for long term or spot sales. Second, European suppliers also have excess capacity, and can add increments of new capacity in several years at low marginal costs, enabling them to aggressively compete with the U.S. for long term contracts. And finally, at least one supplier, Urenco, is seriously investigating the possibility of building an enrichment plant in the United States to compete directly for U.S. sales.

DEVELOPING MINIMUM COST APPROACHES

DOE plans to maintain its existing sales base and build upon it to the maximum extent possible. Additional sales benefit both DOE and its customers by spreading fixed production costs over a greater sales base, thus reducing the average unit cost of DOE's separative work.

DOE has been able to improve its competitive position over the last few years, in large part, by reducing the price it charges for enrichment services. Between 1984 and 1987, the base price has been lowered in real terms by about 30 percent, when inflation is taken into account. Before the US contracts were introduced, the price was over $135 per SWU. As enterprise costs have decreased, there has been a consistent reduction in the base price each year, from $135 per SWU in 1985, to the current price of $119 per SWU.

Competitive pricing must remain a major element of the DOE strategy. In order to effectively compete, DOE must continue to reduce costs and prices. Customers are price conscious and will watch carefully DOE's price during the next few years to determine whether to purchase from DOE or from foreign sources. DOE plans to continue the competitive price trend by offering a reduction in the base price in FY 1988.

Of course, prices cannot be reduced without first reducing program costs. By extensively modifying production, research and development, and construction activities, DOE has reduced program outlays from $1.9 billion in 1984 to about $1.0 billion in 1987. These steps, though difficult, were necessary to restore the competitive position of the U.S. uranium enrichment enterprise.

The Department stopped production of enriched uranium at the Oak Ridge Gaseous Diffusion Plant in 1985. The plant was placed in standby in 1986 so that it could be restarted in the future if needed. The Oak Ridge facility will remain in standby unless needed to meet increased military customer demand. Terminating Oak Ridge plant operations will result in a cumulative cost saving to the enrichment program of about $140 million through FY 1987 and over $290 million through FY 1991. This exceeds by about $40 million the estimated cost saving made at the time of the decision to place this facility in standby.

The decision to terminate construction of the Gas Centrifuge Enrichment Plant (GCEP) was made in June 1985. Very little closeout work remains, and all GCEP and centrifuge development contracts should be completed and the GCEP project officially closed out by September 1987. DOE is currently seeking alternative uses for the GCEP facilities.

The Department currently operates two gaseous diffusion plants (GDPs) in Paducah, Kentucky, and Portsmouth, Ohio. In November 1986, operation of both plants was consolidated under a single contractor, Martin Marietta Energy Systems, Incorporated (MMES). Utilizing one contractor for both GDPs is expected to reduce administrative costs and increase efficiency.

The average cost of production from the GDPs decreased dramatically between 1983 and 1986. This was accomplished by shifting most of the production load to the plant with the cheapest source of power, in effect eliminating the Tennessee Valley Authority (TVA) as a power supplier since their rates have increased by a factor of 6 in 15 years and are now about twice the rates actually being paid at Portsmouth. Savings were also achieved by implementing a more efficient mode of operating the GDPs and by purchasing blocks of lower cost unfirm power when funds permitted. At the same time, the Department has been able to hold the line against inflationary increases despite increased outlays for environmental requirements and increased safeguards and security.

One of the important methods of offsetting cost increases at the GDPs is to obtain more separative work from the electric power delivered to the plant. By continued hard work, DOE operating contractors have increased the efficiency at the plants by improving the separative process and reducing nonproductive power usage. For example, at the Paducah plant, the efficiency has increased over 3 percent since late 1984.

Electric power for operating the GDPs is obtained under long-term contracts with three suppliers: Electric Energy, Incorporated (EEI); the Ohio Valley Electric Corporation (OVEC); and TVA. No electric energy will be purchased from TVA for use in the GDPs in FY 1988. Nevertheless, the Department will be required to pay $549 million in demand charges to TVA during that year. Demand charges are charges for power the Department contracted to purchase in the late 1960's and early 1970's but now does not need or use. Between 1985 and 1987, TVA increased the demand charge component of DOE's rate by 35 percent. The FY 1988 estimate anticipates an 8 percent increase in the demand charge component of TVA's rates. DOE has contested TVA's ratemaking procedures by submitting testimony at TVA's 1986 rate hearings and has attempted to renegotiate future demand charges with TVA.

The DOE contract with TVA for electric power runs through 1994. Because an 8-year lead time is required to cancel power, last year DOE cancelled the last remaining block of power with TVA and notified TVA that no further power will be needed from them. By March 1994, the Department's contract demand will be reduced from the current level of 4,485 megawatts to zero.

In addition, payments totalling $47 million will be made to EEI and OVEC in FY 1988 for power not purchased. This will result from decisions to reduce SWU production and thereby minimize total outlays for purchased power.

Power contracts for the two operating GDPs expire in the late 1980's and early 1990's. To assure a continued supply of power, procurement activities were initiated in 1985. Negotiations between EEI and the Department to supply power to the Paducah GDP were successfully completed in January 1987. After the Department approves and signs the contract, it will be submitted to Congress for review. Negotiations between OVEC and the Department to supply power to the Portsmouth GDP have also been initiated. If negotiations are successful, DOE hopes to submit the contract to Congress for review in September 1987.

Another way to reduce costs is through the economical use of DOE's uranium inventories. During the 1980's, the Department augmented production by selling part of its enriched uranium inventory in order to minimize production outlays while still meeting customer deliveries. From a maximum level of 37 million SWU's in 1980, DOE's inventory of enriched uranium had been reduced to 18.5 million SWU's at the end of FY 1986.

By the end of FY 1988, the Department will have sold all of its remaining preproduced inventory (except that needed for working inventory purposes). DOE's production in FY 1987 is estimated to be 6.3 million SWU's, while sales are estimated to be 11.5 million SWU's. For FY 1988, DOE estimates production at only 4.2 million SWU's, and sales of 12.5 million SWU's. Thus, if these estimates hold, the Department's preproduced inventory will be down to the minimum working level by the end of FY 1988. This means that future annual production will have to match sales, since enriched uranium inventories will have been exhausted.

CHALLENGES TO LONG-TERM COMPETITIVENESS MUST BE RESOLVED

Despite our success in improving our competitive position since 1984 by introducing the new Utility Services contracts, aggressive marketing, and minimizing the cost of our plant operations, it has become increasingly difficult for DOE to manage the enterprise efficiently. Conflicting objectives, varied interpretations of the Atomic Energy Act, and the interplay of competing special interests have each contributed to the present environment within which basic business issues such as pricing, reinvestment, and reliability of service have become unpredictable. Because of these conflicts, customers have expressed concern that they can no longer depend upon DOE as a stable, reliable supplier of enrichment services. The majority of DOE's customers would like to see institutional changes that would insulate the enrichment business from the influence of non-business factors. Their uncertainty and concern will have a major impact on an estimated $5 billion worth of uncommitted sales opportunities through the end of the century. These are now being aggressively pursued by DOE's foreign competitors who are structured more flexibly to capture this market.

The enterprise faces unprecedented challenges that must be resolved now if it is going to continue to provide competitive uranium enrichment services to meet the needs and service requirements of our domestic and foreign commercial customers, as well as U.S. defense programs. Both the long-term viability of the uranium enrichment enterprise and its attractiveness as a candidate for privatization depend upon the favorable resolution of a number of key issues which are currently before the courts or Congress or under review in the Department. These issues include:

- resolution between DOE and the TVA of the appropriate rates and amounts of demand charges for power not taken and no longer needed, in view of significant changes in the determination of these charges by TVA.
- agreement with Congress on the need to price competitively and on the amount of unrecovered Government investment in the enrichment enterprise to be repaid to the Treasury.
- a favorable resolution of pending litigation that challenges the form of the current Utilities Services contract and the "free trade" policy which allows our domestic utility customers to obtain uranium feed stock for enrichment from most foreign sources.
- impact of the 1986 anti-apartheid legislation as to whether our foreign utility customers may send uranium ore or uranium oxide of South African origin into the U.S. for processing (conversion, enrichment, and fabrication) and subsequent re-export to the foreign utility.

Resolution of these issues--coupled with improving the flexibility under which the Government currently manages its uranium enrichment assets--would enhance the value of the enterprise. Our primary objective is to preserve one of the key basic energy industries in the United States. We can and must resolve these challenges now because our failure to do so will likely result in the U.S. losing a secure, long-term domestic fuel supply.

The U.S. enrichment enterprise is not competitive in today's international marketplace even though the current production costs at our GDPs are low. Favorable resolution of these issues would allow us to reduce our prices into the competitive range. If viewed as competitive for the long-term, the United States could hold its current utility customers, and it could win back others.

DOE's APPROACH TO ENSURING LONG-TERM COMPETITIVENESS

As a starting point to assuring long-term competitiveness, there needs to be a consensus reached with this Congress on the objectives of the enterprise. A balanced perspective on these objectives involves energy and national security factors, employment considerations, balance of trade effects, value enhancement for the Government's investment in the enterprise, and our efforts to reduce the Federal budget deficit. Failure to reach consensus on the objectives of the enterprise threatens its future existence. The major asset of the enterprise is the forward value of its enrichment contracts with customers. Customers have begun to terminate these contracts and further erosion of our market share is likely if no action is taken. As contracts are terminated, the value of this important asset--with serious national and energy security implications--decreases.

There was a time in the early 1970's when serious consideration was given to privatizing the enterprise. A major concern of both the Congress and the utilities was that a monopoly owner could engage in monopolistic pricing. These days are gone. The enterprise now operates in a highly competitive market. Failure to act now will only result in foreign competitors becoming the suppliers of U.S. nuclear fuel requirements.

DOE recently concluded that the enrichment enterprise can best meet its commercial obligations and challenges if it is restructured as a Federally-chartered corporation, which can be sold to the public through a stock offering at the appropriate time. The Federal Government would continue to produce highly enriched uranium for U.S. naval forces and other defense needs.

At the core of this recommendation is the belief that maintaining a strong and economical domestic commercial enrichment enterprise is vital to our energy security. Restructuring the enterprise into a corporation can enhance its efficiency and competitiveness and ensure its long-term ability to meet its obligation to the Nation.

We consider that, at a minimum, a corporation chartered by Congress to assume the responsibilities for enriching uranium for commercial customers should be empowered to enrich uranium; engage in related business and relevant aspects of the nuclear fuel cycle; contract with customers and suppliers; conduct research and development, as necessary; raise funds through access to capital markets; retain and reinvest revenues; protect commercially sensitive information; grant access to patents and other proprietary data; operate under generally-accepted private sector accounting, organizational, employment, and operational principles and practices; and resolve any institutional issues regarding the eventual privatization of the enrichment enterprise, including NRC licensing.

The successful formation of such a corporation, of course, requires concurrent resolution of several issues facing the enterprise, including the multi-billion dollar TVA demand charges; the ability to continue the development of advanced enrichment technology; the transferability of current contracts with utilities for enrichment services; the value of the enterprise to be recovered by the Government; future NRC licensing and regulation of the commercial enrichment facilities; Price-Anderson coverage; and the apportionment of eventual decontamination and decommissioning costs between the Government and the enrichment corporation.

We consider the formation of a Federally-chartered enrichment corporation an essential first step for our customers to consider the U.S. as capable of meeting their requirements for low-cost enrichment services. We are eager to begin working with Congress on efforts to restructure the enrichment enterprise to assure its long-term viability and to enable its orderly transition from Government to private ownership. We are confident that these formidable challenges can be met and are ready to begin discussions that will lead to the formulation of enabling legislation this year.

Mr. Chairman, this completes my statement. My colleagues and I would be pleased to respond to your questions at this time.

BIOGRAPHICAL SKETCH

DR. A DAVID ROSSIN

Dr. A. David Rossin was confirmed by the Senate on August 16, 1986, as Assistant Secretary for Nuclear Energy, U.S. Department of Energy (DOE). In this capacity, Dr. Rossin serves as the principal policy advisor to the Secretary of Energy and Administration spokesman on nuclear energy. Dr. Rossin manages an organization responsible for reactor development and demonstration programs; advanced reactor research and development; programs to develop and apply advanced nuclear systems technology to space and defense power systems, including power supply systems for the President's Strategic Defense Initiative; remedial action and waste technology activities; and manages the U.S. uranium enrichment enterprise.

Prior to his nomination by the President and subsequent Senate confirmation to this position, Dr. Rosin directed the Nuclear Safety Analysis Center at the Electric Power Research Institute (EPRI) in Palo Alto, California. From 1972 to 1981, Dr. Rossin served in various positions at Commonwealth Edison Company in Chicago, Illinois. His last position was Director of Research for the company. While associated with Commonwealth Edison, Dr. Rossin served on a number of corporate, industry, and scientific advisory committees and chaired advisory committees for the EPRI Safety and Analysis Department and the Systems and Materials Department.

Dr. Rossin served in a variety of technical and managerial positions at Argonne National Laboratory from 1955 to 1972. His work at Argonne involved the design of experimental power reactors, particularly the radiation shielding design and safety analyses. During this period, Dr. Rossin began research on the effects of intense neutron radiation on the steel pressure vessels surrounding the core of light water reactors. This field of research was the subject of his doctoral thesis and numerous publications. He served for ten years on Argonne's Reactor Safety Review Committee, one year as its Chairman.

A native of Cleveland, Ohio, Dr. Rossin received his B.S. degree in engineering physics from Cornell University in 1954; his M.S. degree in nuclear engineering from the Massachusetts Institute of Technology in 1955; his M.B.A. degree from Northwestern University in 1963; and, his Ph.D. degree in metallurgy from Case Institute of Technology in 1966.

Dr. Rossin and his wife, Sandra, have two daughters.

STATEMENT OF BEN C. RUSCHE, DIRECTOR, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, U.S. DEPARTMENT OF ENERGY

Mr. Chairman and Members of the Subcommittee:

I am pleased to present to you detailed information concerning the 1988 budget for the U.S. Department of Energy's (DOE's) Office of Civilian Radioactive Waste Management. It includes major activities planned for FY 1988 under the Nuclear Waste Fund program, as well as under the Civilian Radioactive Waste Research and Development program, and provides a current status of implementation of and plans under the Nuclear Waste Policy Act of 1982 (NWPA). Since the NWPA requires the annual submission of a triennial budget under the Nuclear Waste Fund, in my discussion of the FY 1988 Nuclear Waste Fund program, estimates for FY 1989 and FY 1990 are included.

BUDGET OVERVIEW

The FY 1988 funding level required to carry out the program as in the recently issued draft Mission Plan amendment is estimated to be $725 million. However, the actual funding level requested at this time is $500 million. This is based upon the recognition that Congressional direction provided in the FY 1987 Continuing Resolution indicated the need to interact with Congress and to resolve external issues before moving at the pace we believe is necessary.

Appropriation for the higher funding level ($725 million) would be appropriate after satisfactory resolution of the issues presented in the draft Mission Plan amendment and outlined in the FY 1988 funding estimate. Therefore, upon satisfactory resolution of the issues, an amendment to the FY 1988 budget request is planned to be submitted to provide the required funding to carry out the program as described in the funding estimate.

The NWPA created the Nuclear Waste Fund, which is financed by fees collected from owners and generators of spent nuclear fuel and high-level radioactive waste. The FY 1988 funding estimate for the Nuclear Waste Fund is $725 million, compared to $499 million appropriated in the Continuing Resolution for FY 1987. The Nuclear Waste Fund budget estimate for FY 1989 is $1.10 billion and for FY 1990 is $1.06 billion.

Research and development (R&D) activities not financed under the Nuclear Waste Fund are funded under the Energy Supply R&D appropriation in a program entitled Civilian Radioactive Waste R&D. The FY 1988 budget request for Civilian Radioactive Waste R&D is $5 million, compared to $6.5 million in FY 1987.

The FY 1988 budget request for budget authority funded by the Nuclear Waste Fund is summarized in Table 1. The FY 1988 Departmental budget request for Civilian Radioactive Waste R&D is summarized in Table 2. Under the Nuclear Waste Fund, the FY 1988 estimate will provide for extensive site characterization activities, including the start of exploratory shaft construction, and intensive engineering tests and analyses to support the waste package and repository designs for the first repository. Actual exploratory shaft construction is planned to commence in FY 1988 at two of the three candidate repository sites approved by the President May 28, 1986, for site characterization.

The FY 1988 funding estimate will also provide for non-site-specific technical studies in alternative geologic media to determine their suitability for hosting a second geologic repository. A significant portion of these studies is expected to involve cooperative efforts with other countries. While construction of a second repository is not authorized by Congress, DOE is committed to a two-repository system and, based on a number of factors to be discussed later, DOE believes that the earliest the Congress needs to consider site-specific work for a second repository is in the mid- to late-1990s.

In addition to an increase in the budget related to first repository site characterization activities, the FY 1988 funding estimate also represents an increase over FY 1987 in activities related to the Monitored Retrievable Storage (MRS) program, should Congress adopt the proposal required by Section 141 of the NWPA, and which we submitted on March 31, 1987. The FY 1988 estimate of $58 million compared to $20 million in FY 1987 assumes Congressional approval to proceed with activities that are critical to the deployment of an MRS facility. In that proposal, DOE recommends the construction of an MRS facility centrally located to the majority of spent fuel generated to receive, consolidate and package spent fuel for bulk shipment to a permanent repository.

The program proposed to be funded from the Nuclear Waste Fund is designed to ensure that the activities and facilities authorized by the NWPA are carried out in a vigorous and responsible manner.

The Act authorized a number of key activities, that, taken together, will meet the objective of providing for the timely and permanent disposal of spent fuel and high-level radioactive waste. Specifically, the NWPA authorizes the siting, development and operation of a geologic repository and the necessary transportation system for moving the wastes to the repository. These authorities along with other key requirements stated in the NWPA -- including the need to obtain Congressional authorization for the construction of a second repository and an MRS facility -- constitute the set of activities necessary to implement the NWPA. These activities reflect the clear intent of the NWPA, and their successful completion will result in meeting the following goals and objectives of the Civilian Radioactive Waste Management Program:

1. To site, obtain licenses for, construct and operate by January 31, 1998, a waste management system such that

the disposal of spent fuel and high-level waste from commercial nuclear power plants and high-level radioactive waste from atomic energy defense activities can be accomplished in a manner that is safe and environmentally acceptable and in conformance with the NWPA.

2. To conduct a technical program of non-site-specific studies into the suitability of alternative geologic media for a second repository.

3. To develop and operate a safe, efficient system to transport spent fuel and high-level waste from sources of generation or storage to the disposal destination.

TABLE 1

FY 1988 CONGRESSIONAL BUDGET
NUCLEAR WASTE FUND
($in Thousands)

	FY 1987 Approp.	FY 1988 Request
NUCLEAR WASTE FUND		
Repository Development		
o First Repository	$307,446	$525,044
o Second Repository	19,800	24,000
Monitored Retrievable Storage	20,000	58,000
Transportation and Systems Integration	26,000	63,043
Program Management and Technical Support	46,754	54,913
	79,000 a/	
TOTAL	$499,000	$725,000
Less		225,000 b/
FY 1988 CONGRESSIONAL BUDGET REQUEST		$500,000
Projected Receipts		
o One mill/KWh fee	$434,600 1/	$481,300 1/
o One-time fee	6,000	31,200
TOTAL	$440,600	$512,500
Interest Income	$133,500 2/	$136,300 2/
TOTAL	$574,100 2/	$648,800 2/
Staffing Full-Time Equivalents (FTE's)	311	357

a/ DOE reserve pending satisfactory completion of the terms contained in the Continuing Resolution, P.L. 99-500 and P.L. 99-591.

b/ The funding level required to carry out the program as described in the Department of Energy's budget and in this statement and shown in the draft amendment to the Mission Plan is estimated to be $725 million. The President's request is based upon the recognition that Congressional direction provided in the FY 1987 Continuing Resolution indicated the need to interact with Congress and to resolve external issues before moving forward as planned. A request for a higher funding level would be appropriate presuming satisfactory resolution of these issues. Therefore, upon satisfactory resolution, an amendment to the FY 1988 budget will be submitted to provide the required funding to carry out the program described herein.

1/ Based on projected net nuclear electricity generation as a result of the recent Wisconsin court decision. (Wisconsin Electric Power Company, et al., vs. Hodel, 84-8571 (decided December 6, 1985)).

2/ Based on projected average yield of Treasury security portfolio

TABLE 2

FY 1988 CONGRESSIONAL BUDGET
ENERGY SUPPLY RESEARCH AND DEVELOPMENT ACTIVITIES
($ in Thousands)

	FY 1987 Approp.	FY 1988 Request
CIVILIAN RADIOACTIVE WASTE R&D		
Spent Fuel Storage Development	$ 6,300	$ 4,800
Alternative Disposal Concepts	-----	------
Program Direction	200	200
TOTAL	$ 6,500	$ 5,000
Staffing FTE's	3	3

An increase in Transportation and Systems Integration in FY 1988 is also shown. The FY 1988 request of $63.0 million compared to the FY 1987 appropriation of $26 million from the Nuclear Waste Fund represents the completion of design and the fabrication of scale models for the transportation casks; implementation of a comprehensive public information plan and the development of information resources; increased reactor infrastructure evaluations and operations configuration studies; and publication of the Comprehensive Transportation Plan. In addition, for systems integration, the increase is primarily attributable to engineering development. Contracts will be awarded for final design, hardware fabrication and demonstration of the rod consolidation process. And systems analysis activities will increase to ensure the overall waste management system is integrated into an efficient, cost-effective system.

The FY 1988 budget request under the Civilian Radioactive Waste R&D program of $5 million represents a decrease from the FY 1987 budget of $6.5 million. Essentially, this results from the fact that two of the three cooperative demonstrations being carried out under Section 222 of the NWPA will be completed during FY 1988 and the final reports will be issued.

NUCLEAR WASTE FUND PROGRAM

I would like now to give a brief status of the program.

In January, we released a draft amendment to the Mission Plan for the Civilian Radioactive Waste Management Program. We have sent it to States and affected Indian Tribes, the Nuclear Regulatory Commission (NRC) and other Federal agencies for comment and have made it available for public inspection. During the 60-day comment period, we plan to meet with affected States and Indian Tribes to answer any questions they may have regarding the amendment that may assist them in formulating their formal comments. To date, we have had one such meeting. At the Quarterly Meeting with States and affected Indian Tribes in Spokane, Washington, on February 12, the draft amendment was a major topic of discussion.

The purpose of the Mission Plan amendment is to keep Congress, as well as others, informed on progress in the program. When the Mission Plan was issued in 1985, we said it is "today's best estimate of the scientific, engineering and institutional information needed to make informed decisions as we proceed with developing ... the disposal system." We explained that it is a planning document, and as such, we would review it annually and revise it on an as-needed basis. The purpose of amending the

Plan is to ensure that it reflects current significant developments and plans.

The draft amendment is the first such amendment and presents our estimate of how and on what schedule we believe we can best fulfill our responsibilities in carrying out the program. After the 60-day comment period, we will revise the amendment in response to the comments as appropriate and will submit it formally to Congress.

The focal points of the draft Mission Plan amendment are:

- o Achievements in the first repository program, including the nomination and recommendation of sites for detailed site characterization;
- o As a result of reevaluations of the work necessary to proceed, a five-year extension of the schedule for the first repository;
- o New waste-generation data that, along with other considerations, indicate that it is prudent to indefinitely postpone site specific activities for the second repository while continuing technical development activities;
- o Developments concerning the submission to Congress of a proposal for an MRS facility as an integral part of the waste management system; and,
- o Actions taken and progress made toward better defining the consultation and cooperation process with eligible States and affected Indian Tribes.

We recognize that there are particular matters of significant Congressional concern, and we hope to receive Congressional direction in these areas.

First Repository

Last May, DOE nominated five sites in Mississippi, Nevada, Texas, Utah and Washington as suitable for characterization and issued Environmental Assessments for each of those sites. The Secretary recommended to the President three of those sites for characterization as candidates for the first repository. The three sites are: the Yucca Mountain site in Nevada, the Deaf Smith County site in Texas and the Hanford site in Washington. The President approved the Secretary's recommendation and that action formally marked the beginning of the site characterization phase.

This represented a major milestone in the siting of the first repository and years of work in gathering and analyzing geologic and environmental data from site studies that began before passage of the NWPA. Reaching this stage of determination permits us to thoroughly investigate, evaluate and compare geologic, environmental, transportation and safety factors at each of the three sites.

Site characterization will take five-to-seven years, depending on the site. It includes laboratory investigations; surface-based data-collection activities, such as geologic mapping and seismic surveys; studies conducted through the drilling of boreholes; and studies conducted in and around the candidate host rock in exploratory-shaft facilities.

Although we had planned to begin exploratory shaft construction at one or two of the sites this fiscal year, Congress, in the appropriation for the waste program for FY 1987, specified that no funds are to be used for drilling any exploratory shaft at any site in FY 1987. However, Congress did allow for site-specific work, other than exploratory shaft drilling, to be conducted at reduced funding levels.

The current activities at or related specifically to each of the candidate sites, include the following:

o At the Nevada site, land access is being pursued with other Federal agencies.

o At the Washington site, site plans are proceeding for hydrology tests that will precede exploratory shaft drilling.

o At the site in Texas, DOE is proceeding with its plans for obtaining access to the land. In late February, we met with property owners and held public meetings in Texas near the Deaf

Smith County candidate site to describe project activities, studies and land access plans for the site and to answer questions. In addition, about 10 people from the DOE Salt Repository Project Office and the support contractor have moved from offices in Columbus, Ohio, to temporary office trailers placed on land leased by DOE near Vega. As of March 2, they are available on a daily basis to respond to questions about job and contracting opportunities for local people and to assist in locating permanent office facilities for the project. Texas, unlike the Nevada and Washington candidate sites, has had no DOE office for this program located near the site or in the State.

Two major efforts under the NWPA and associated with the beginning of site characterization are:

1. Negotiations for formal consultation and cooperation; and,
2. The development of site characterization plans.

The NWPA requires DOE to seek to enter into and negotiate written Consultation and Cooperation (C&C) agreements with States and affected Indian Tribes after approval of candidate sites for characterization, or earlier, if an eligible State or Indian Tribe requests. Some negotiations have occurred, but as yet no C&C agreements have been concluded.

Given the nature of the program and the reality that the perspectives of the States and affected Indian Tribes often differ from DOE's, we recognize that C&C agreements may not be easy to reach. We plan to increase our efforts to negotiate C&C agreements. In this regard, we are considering a number of new initiatives to encourage these negotiations. For example, DOE is willing to consider the adoption and implementation of de facto agreements or memoranda of understanding that would contain less than is required to be in the C&C agreements, should the State or affected Indian Tribe find this advantageous. This could allow both parties to adopt agreed-on procedures immediately, even before the C&C agreement is fully developed. Such an approach is attractive because it recognizes the importance and the achievements of the negotiation process that has been under way since the NWPA was signed into law.

But C&C negotiations and agreements are but one part of the process of working with affected parties. Interactions with affected and interested parties occur every day.

In addition, there have been a number of actions outside formal C&C negotiations which have been taken recently as a result of recommendations. For example:

- The participation by States and affected Indian Tribes in DOE coordinating groups; and,
- The expansion of the Quarterly Meetings with States and affected Indian Tribes for the public to attend.

There are currently twelve Coordinating Groups and they are listed in Table 3. The Coordinating Groups meet two-to-four times per year and provide a forum for the discussion of common problems and their resolution. It is expected that additional coordinating groups will be established and existing ones abolished as requirements and priorities change.

Since Summer 1984, Quarterly Meetings have been held with States and affected Indian Tribes to discuss topics mutually agreed upon for the agenda. As a result of recommendations by the States and Indian Tribes, these meetings will now be open to the public. The first such meeting was held on February 12 in Spokane, Washington. The agenda was coordinated among the States, the Indian Tribes and DOE and a public announcement was made by the nearest DOE Operations and Project Office in Richland, Washington. As mentioned earlier, the draft Mission Plan amendment was a major topic of discussion at the meeting.

I mention these activities because I believe it is important to point out that while formal consultation and cooperation

Table 3

EXISTING COORDINATING GROUPS

The following coordinating groups are currently in existence and supported by their own charters:

- Site Characterization Plan Coordinating Committee
- Geoscience Coordinating Group
- Repository Coordinating Group
- Waste Package Coordinating Group
- Performance Assessment Coordinating Group
- Licensing Coordinating Group
- Quality Assurance Coordinating Group
- Transportation Coordinating Group
- Institutional Affairs Coordinating Group
- Project Management Coordinating Group
- OCRWM Information Resources Management Coordinating Group
- Environmental Coordinating Group

negotiations are only required to begin after a candidate repository site is approved for site characterization, consultation and cooperation is an everyday activity and responsibility -- DOE's responsibility, the States' and Indian Tribes' responsibility -- the responsibility of all the affected parties to consult and to cooperate.

Site Characterization Plans

Another major effort associated with site characterization is the preparation of a plan for characterizing each site. This plan -- called a site characterization plan (SCP) -- is a major and intensive effort. For example, the scope and magnitude of this effort can be gauged from the SCPs now being prepared for publication: in each plan, the description of the characterization program alone covers several thousand pages.

Copies of each draft chapter of the SCPs are being shared with the NRC, States and affected Indian Tribes for comment as they become available. The NWPA requires that such a plan for any candidate site be prepared, made available to the public and that public hearings be held by DOE in the vicinity of a candidate site before proceeding to sink the exploratory shafts at the site.

The SCPs are key documents and of major importance to States, Indian Tribes and the public -- as well as to NRC and to us. These plans will contain:

- A detailed specification of the information to be developed for each site, the conceptual waste package and repository design, and the issues to be addressed;
- Schedules for a logical sequence of testing and the timing for the issuance of publications on technical procedures, technical findings, and issue resolution; and,
- Milestones and decision points to be encountered along the way.

There is intense interest in the SCPs, since the SCPs will guide DOE during the site characterization phase until a license application is submitted to the NRC. The SCPs and periodic progress reports that DOE will be making, will have a crucial role in interactions with the NRC, and as vehicles for presenting information to the States, Indian Tribes, Congress, utilities and the public.

The main purpose of site characterization is to determine whether a candidate site is suitable for a repository and to provide the bases for the selection of a repository site and for the construction authorization and license application request to the NRC -- tasks that have never been done before. Therefore, finding answers to relevant questions is the main focus of site characterization.

First Repository Schedule

The experience gained in achieving the important milestone of approval of sites for characterization, and advances in the technical planning of the program, have led us to reassess the program and schedule for the first repository. The new schedule -- as presented in the draft Mission Plan amendment -- shows a 5-year extension of the date for the waste acceptance at the first repository, from 1998 to 2003.

This 5-year extension of the operation of the first repository is primarily a result of additional time needed in the near term. This is not the first time that we have come to realize that additional time is needed to carry out certain activities required by the NWPA. To better illustrate where additional time has been needed and where we believe it is needed now, Table 4 in my statement shows the current schedule as compared to the schedule contained in the NWPA and in the 1985 Mission Plan.

There are several reasons for the near-term extension. Among them are:

o The experience to date that more time has been required to involve States and Indian Tribes in review and discussion.

o The recognition that more time should be provided in the future for consultation and interaction with the States, affected Indian Tribes, and other parties; and,

o The recognition that more technical information is needed.

Since passage of the NWPA, many parties have insisted that, given the controversial nature of the program, the schedule specified in the Act was not realistic and not achievable. And on several occasions, the schedule and processes prescribed in the NWPA have been expanded, as shown in Table 4, to provide additional time for input by affected and interested parties, for additional review of DOE actions or documents and for incorporation of comments or resolution of issues.

TABLE 4.

NUCLEAR WASTE POLICY ACT MILESTONES

COMPARISONS WITH NWPA, JUNE 1985 MISSION PLAN, AND DRAFT AMENDMENT TO THE MISSION PLAN

ACTIVITY	NWPA REQUIREMENT	1985 MISSION PLAN	1987 DRAFT AMENDMENT	ACTUAL
1. Identify States w/ potentially acceptable sites	4/7/83	--	--	2/2/83
2. State/Tribal notification as to being potentially acceptable sites	7/7/83	--	--	2/2/83
3. Issue Siting Guidelines	7/7/83	12/84	--	12/84
4. Issue Mission Plan	5/84	--	--	6/85
5. Issue Environmental Assessments	--	11/85	--	5/86
6. 1st Repository Nomination/Recommendation of sites suitable for characterization	1/1/85	11/85	--	5/86
7. Presidential Approval of sites	--	1/86	--	5/86
8. Seek to enter into C&C agreements	7/86	--	--	7/86 *
9. Issue SCP's	--	3/86 tuff 3/86 basalt 10/86 salt	mid-87 tuff mid-87 basalt 1st Qt.88 salt	-- -- --
10. Initiate Construction of Exploratory Shafts	--	3rd Qt. 86 tuff 3rd Qt. 86 basalt 3rd Qt. 87 salt	2nd Qt. 88 tuff 3rd Qt. 88 basalt 4th Qt. 89 salt	-- -- --

* Informal C&C negotiations were initiated with the State of Washington, and the Yakima and Umatilla Indian tribes in mid-1983.

ACTIVITY	NWPA REQUIREMENT	1985 MISSION PLAN	1987 DRAFT AMENDMENT	ACTUAL
11. Testing to support DEIS complete	--	12/89	1st Qt. 92 tuff 1st Qt. 93 basalt 1st Qt. 93 salt	-- -- --
12. Issue FEIS	--	12/90	4th Qt. 1994	--
13. President recommends site to Congress	3/31/87	3/91	4th Qt. 1994	--
14. Site designation effective	5/91	5/91	1st Qt. 1995	--
15. Submit License Application to NRC	--	5/91	1st Qt. 1995	--
16. NRC issues Construction Authorization	--	8/93	1st Qt. 1998	--
17. Initiate Repository Construction	--	8/93	1st Qt. 1998	--
18. NRC issues License for Phase 1 Operations	--	12/97	1st Qt. 2003	--
19. Phase 1 Repository Operations begins	--	1/98	1st Qt. 2003	--
20. Phase 2 Repository Operations begins	--	2/01	2nd Qt. 2006	--
1. 2nd Repository Nomination/Recommendation of sites suitable for characterization	7/1/89	10/91	mid- to late-90s	
2. President recommends 2nd Repository site to Congress	3/31/90	3/98	2010 to 2020	

1. Submit to Congress report describing R&D activities necessary to develop MRS proposal	7/83			6/83
2. Submit to Congress detailed study on the need for and feasibility of MRS	6/1/85	1/86	As soon as permitted	3/31/87

At my confirmation hearing almost three years ago, I pledged that the schedule would not be allowed to prevail at the expense of technical excellence, safety and public participation. And I continue to maintain that position. I respect the timetables, but where additional time appears to be needed to ensure the quality of the product, as a manager, I must recommend additional time.

We now recognize that more information, more consultation and more time is required in the near term to ensure development of the first repository for long-term (permanent) disposal. We will remain optimistic in our planning, but realize that for many early actions, we underestimated the time required. Furthermore, DOE recognizes the potential for contingencies that are yet to appear.

The FY 1988 funding estimate for first repository activities is $525 million compared to the FY 1987 appropriation of $307.5 million. This increase is primarily due to exploratory shaft construction which is planned to commence at the Nevada site and at the Washington site in FY 1988.

The FY 1989 budget estimate for first repository activities is $869.6 million and the FY 1990 budget estimate is $829.7 million.

Second Repository

The NWPA authorizes siting of a second repository, but does not authorize its construction.

The FY 1988 funding estimate for non-site-specific second repository activities is $24 million compared to the FY 1987 appropriation of $19.8 million. The estimate for second repository activities remains at $24 million for both FY 1989 and FY 1990.

I would like to point out, again, that we plan to propose construction of a second repository. In fact, even the lowest current projections of spent fuel generation indicate that the second repository will be needed. DOE, therefore, remains fully committed to a two-repository system.

Our current program regarding second repository focuses on technology development. A significant portion of these studies is expected to involve cooperative efforts with other countries through continuation of the current program of international cooperation, such as that with Canada where we are participating in the extension of the depth of the shaft at their Underground Research Laboratory in Manitoba, near Winnipeg.

A requirement related to the second repository is stated in the NWPA in terms of the maximum amount of spent fuel that the NRC can allow to be emplaced in the first repository until a second repository is in operation. The NWPA sets this figure at 70,000 metric tons of uranium.

Under the revised schedule for the first repository, this limit would be reached sometime after the year 2025 if the maximum annual rate of waste emplacement is 3,000 metric tons. DOE believes the actual schedule for consideration of the second repository should be based on more-refined estimates of spent fuel generation rates, the time needed for the first repository to reach the limit of 70,000 metric tons and the time needed to develop the second repository.

The experience in siting the first repository suggests that site-specific screening leading to the identification of potentially acceptable sites should start about 25 years before the start of waste acceptance for disposal. Therefore, to have the second repository available by about 2025, site specific studies need not start until the mid- to late-1990s.

For the second repository, DOE may consider sites identified as potentially acceptable but not nominated for the first repository, sites found potentially acceptable from rock formations not previously studied in the first repository selection process and sites characterized but not chosen for the first repository site.

A rock type not previously studied in the first repository selection process has been crystalline rock. Following national surveys, DOE identified 235 crystalline rockbodies in 17 States in three regions -- the North Central, the Northeast and the Southeast parts of the country.

In the "regional phase" of investigation, DOE collected and assessed publicly available geologic and environmental data, reviewed these data with the States and prepared Regional Environmental and Geologic Characterization Reports for each of the three Regions. In addition, through workshops and other interactions with the crystalline States, DOE prepared a Region-to-Area Screening Methodology to be used for narrowing down the 235 rockbodies to a small number of areas preferred for further study.

On January 16, 1986, following application of the Screening Methodology to the data contained in the Regional Characterization Reports, we issued for public comment a Draft Area Recommendation Report (ARR).

Based on the Secretary's announcement in May 1986 to postpone indefinitely site-specific work for a second repository until the mid- to late-1990s, DOE is now cataloging the more than 60,000 comments received on the Draft ARR. Based on the schedule represented in the draft amendment to the Mission Plan and approval of DOE's plans presented therein, DOE plans to begin with national surveys when site-specific efforts are later considered.

Monitored Retrievable Storage

The FY 1988 funding estimate assumes the Congress will allow DOE to proceed with activities that are critical to deployment of an MRS facility. With this in mind, the FY 1988 estimate for MRS activities is $58 million compared to the FY 1987 budget appropriation of $20 million. These funds would be used primarily for site data collection and analysis, final design of the facility itself, regulatory compliance studies and State liaison activities. The schedule for construction of the MRS allows about ten years from the time Congress approves our proceeding to the start up of operations. The FY 1989 estimate is $66 million and the FY 1990 estimate is $68 million.

The NWPA (Section 141) directs DOE to complete a study of the need for and feasibility of an MRS, and to submit to the Congress a proposal for the construction of one or more MRS facililties. The NWPA specifies that the proposal include a program for siting, development, construction and operation of an MRS facility; site specific designs and cost estimates for the construction of such a facility, should Congress approve its construction; a plan for funding the construction and operation of such a facility; and a plan for integrating such a facility into the overall Federal waste management system.

In spring of 1985, DOE completed a preliminary analysis of the need for and feasibility of an MRS facility and announced our conclusion that such a facility could serve as an integral and important part of the overall waste disposal system. With approval of Congress, we reprogrammed funds to allow us to prepare the full MRS proposal. We identified a preferred site and two alternative sites, as required by the NWPA. In addition, we completed the need and feasibility studies verifying our tentative conclusions. We paid special attention to evaluating the no-MRS case.

We worked closely with the State in our development of the proposal to Congress. This interaction has principally been through the Governor's Safe Growth Council. To support their review of the proposal, we provided a grant of $1.4 million. The State in turn provided $100,000 each to two local community groups to study the MRS proposal.

The Clinch River MRS Task Force completed their review in October 1985 and issued a report entitled "Recommendations on the Proposed Monitored Retrievable Storage Facility." In their report, the Task Force concluded that an MRS could be safely constructed and operated. In addition, Task Force members from the City of Oak Ridge and from Roane County passed resolutions stating that an MRS facility would be acceptable if certain conditions were met. In our proposal to Congress, we have attempted to meet those conditions.

In mid-December 1985, and as required by the NWPA, we submitted to the NRC and to the Environmental Protection Agency (EPA) review copies of the Proposal to Congress, the Environmental Assessment on the MRS and an MRS Program Plan. At the same time, we provided copies to the State.

In January, 1986, the Governor met with the Secretary of Energy and me to present the State's position on our proposal to construct an MRS at the Clinch River site. We were disappointed that the then Governor did not share our view of the need for and value of an MRS. We are pleased that he, like the Clinch River MRS Task Force, shared our view that such a facility could be constructed and operated safely and is not a substitute for a permanent repository.

The proposal submitted to Congress on March 31 is accompanied by NRC comments and EPA comments as well as the State and local community group comments.

In our proposal, we recommend that Congress:

- Approve the construction of an MRS facility at a specific site;
- Limit the storage capacity at the MRS facility to 15,000 metric tons of spent fuel;
- Preclude waste acceptance by the MRS facility until a construction authorization for the first repository is received from the NRC;
- Direct DOE to implement measures responsive to the concerns and recommendations of the State and local governments; and,

- Direct DOE to implement the program plan accompanying the proposal.

In accordance with other provisions of the NWPA, should Congress approve proceeding with an MRS facility, we are committed to seeking immediately to enter into a formal Consultation and Cooperation Agreement with the host State.

Nuclear Waste Fund

In April 1983, DOE adopted a fee of one mill (one-tenth of a cent) per kilowatt hour charged to utilities for all nuclear-generated electricity beginning April 7, 1983, as specified in the NWPA. Revenues collected from the on-going fee by DOE through December 31, 1986, total approximately $1.3 billion.

In addition to spent fuel generated since April 7, 1983, spent fuel or high-level waste generated prior to that date is subject to a fee equivalent to an average charge of one mill per kilowatt hour. Utilities had until June 1985 to decide on one of three payment options. Those who chose to pay in one lump sum by June 1985, to save interest charges, made payments totalling more than $1.4 billion. This represents more than half of the one-time fee liability of $2.3 billion for civilian nuclear waste in existence prior to April 7, 1983. Following receipt of these monies, DOE reimbursed the U.S. Treasury approximately $265 million, the total amount owed on the appropriated debt transferred to the Nuclear Waste Fund upon enactment of the NWPA.

In April 1985, the President accepted DOE's recommendation to dispose of defense waste in a commercial repository. The Federal Government, therefore, will pay an equivalent fee to that paid by utilities. This use of the repository will generate additional revenue for the Fund. The amount of the additional revenue is presently being determined and, therefore, is not included in our revenue estimates.

In early December 1986, we issued in the Federal Register a Notice of Inquiry describing three methodologies for the determination of equitable payments into the Waste Fund by the Department of Energy's Office of Defense Programs. The 60-day comment period ended February 2. We have received comments from about two dozen responders including public utility commissions, utilities and states.

The revenue projections based on the one mill per kilowatt hour fee are shown in Table 5.

TABLE 5

NUCLEAR WASTE FUND REVENUE PROJECTIONS
($ in millions)

FY 1983 (actual)	$ 73.6	
FY 1984 (actual)	329.5	
FY 1985 (actual):		
-One mil/KWh	367.3	
-One-time fee	1,427.4	
-Interest Earned	32.7	
FY 1986 (actual):		
-One mil/KWh	362.3	
-One-time fee	5.5	
-Interest Earned	146.0	
FY 1987:		
- One mil/KWh	434.6	a/
- One-time fee	6.0	
- Interest Earned	133.5	b/
FY 1988		
-One mil/KWh	481.3	a/
-One-time fee	31.2	
-Interest Earned	136.3	b/
FY 1989		
-One mil/KWh	507.4	a/
-One-time fee	39.6	
-Interest Earned	126.1	b/
FY 1990		
-One mil/KWh	534.1	a/
-One-time fee	39.6	
-Interest Earned	111.6	b/

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a/ Based on projected net nuclear electricity generation as a result of the recent Wisconsin court decision. (Wisconsin Electric Power Company, et al., vs. Hodel, 84-8571 (decided December 6, 1985)).

b/ Based on projected average yield of Treasury security portfolio.

Transportation and Systems Integration

The FY 1988 funding estimate for activities associated with Transportation and Systems Integration is $63 million. The FY 1989 estimate is $79.9 million; and the FY 1990 estimate is $78.7 million.

The FY 1988 major activities include fabrication and testing of prototype casks for truck, rail and barge transports and public review of designs; and fabrication and testing of prototypical rod consolidation hardware. Work will be continued to support institutional programs including national and regional workshop completion and publication of a comprehensive transportation plan and issue resolution.

In addition, systems integration activities include systems analysis and engineering development to ensure that the waste system components are fully integrated into an efficient, safe and timely waste management system, and to develop equipment to consolidate spent fuel assemblies on a production-line basis to adequately meet requirements of receiving facilities.

Program Management and Technical Support

The FY 1988 budget request for program management and technical support is $54.9 million. The FY 1989 estimate is $62.2 million; and the FY 1990 estimate is $63.3 million.

The FY 1988 funding estimate of $54.9 million provides technical support for waste management activities including (a) technical support integration, (b) development of standard materials characterization methods by the Material

DOE's Civilian Radioactive Waste R&D program efforts are to utilize all means directed or available through the Act or other authority to encourage and expedite the availability of licensed new at-reactor storage technologies.

Spent Fuel Storage R&D

DOE's spent fuel storage development program is intended to encourage and expedite the most efficient use of existing storage facilities and the addition of new, licensed capacity in a timely fashion. In FY 1986, as a result of cooperative agreements between DOE and utilities, two independent spent fuel storage installations were licensed by NRC. These demonstrations will be completed in FY 1988. In addition, another rod consolidation demonstration of spent fuel as part of a cooperative agreement with Northeast Utilities Services Company will be completed. We plan to continue cooperative activities in information exchange regarding spent fuel storage and disposal with non-nuclear weapon states and to continue to participate in international activities with the International Atomic Energy Agency, the Nuclear Energy Agency and the Federal Republic of Germany.

Program Direction

The FY 1988 budget request for program direction is $.2 million. At this level, three full-time equivalents would be funded to manage the Civilian Radioactive Waste R&D programs. Included are administrative and technical personnel who manage a broad range of activities such as: research, development, demonstration, industrial involvement and international programs. Characterization Center, and (c) supporting studies including fund management activities.

This funding level provides for a staffing level of 357 full-time equivalent (FTE) positions at headquarters and in the Operations Offices for fund management, site investigation, technology development and institutional liaison associated with the technical management of the repository, MRS (if approved), supporting programs and the management of the Nuclear Waste Fund. This is an increase over the FY 1987 level of 311, due primarily to site characterization activities. Increases in FTE levels would principally occur in the field offices.

The FY 1989 and FY 1990 estimates of $62.2 million and $63.3 million, respectively, will provide for program management and technical support associated with site characterization activities at all three candidate repository sites and increasing effort in transportation systems development. Major emphasis will continue on developing an integrated cost-effective waste disposal system providing full protection of public health and safety and the environment.

CIVILIAN RADIOACTIVE WASTE R&D PROGRAM

Development and demonstration activities under the Civilian Radioactive Waste R&D Program are funded from the General Fund rather than funds collected from the utilities and deposited into the Nuclear Waste Fund.

The FY 1988 budget request for the Civilian Radioactive Waste R&D activities is $5 million compared to $6.5 million in FY 1987.

Conclusion

In summary, the FY 1988 programs described in this statement are designed in an efficient and effective manner to achieve the national mandate of the NWPA to develop a comprehensive and functional waste disposal system for spent fuel and high-level waste.

This concludes my remarks in support of the FY 1988 Nuclear Waste Fund and R&D programs. I shall be pleased to answer your questions at this time.

BIOGRAPHICAL SKETCH

BEN C. RUSCHE

Ben C. Rusche is Director of the Office of Civilian Radioactive Waste Management, U.S. Department of Energy (DOE). This is a new position, and carries with it the responsibility for dealing with the nation's nuclear waste problems as mandated by the Nuclear Waste Policy Act of 1982.

Before coming to DOE, Mr. Rusche was serving as President of Management and Technical Resources, Inc., and also served as a consultant to Secretary of Energy Donald Paul Hodel. He was Vice President of Management Analysis Company from 1982 to 1984; a member of the Nuclear Regulatory Commission Task Group of the President's Private Sector Survey on Cost Control in 1982; and Special Assistant for Policy and Programs for Energy Secretary James B. Edwards, 1981-82.

He was Director of the South Carolina Energy Research Institute from 1978 until joining DOE in 1981, and while on leave of absence from that post served as Director of Waste Management, Three Mile Island Recovery Operations, for General Public Utilities Corporation, overseeing a major portion of that recovery effort.

From 1977 to 1978, Mr. Rusche was Director of Health and Safety for E.I. DuPont de Nemours & Co. From 1975 to 1977, he served as Director, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC). He held various management positions at the Savannah River Laboratory from 1960 to 1975, was Senior Nuclear Engineer at Lockheed Aircraft Corporation from 1958 to 1960, and served as Nuclear Physicist at the Savannah River Plant from 1953 to 1958.

In 1953, Mr. Rusche received a B.S. degree in physics from the Tennessee Polytechnic University and did graduate work in reactor engineering at the Georgia Institute of Technology.

Mr. Rusche received the NRC Award of the Year for Outstanding Management Ability in 1976. His current and past organizational memberships include the American Association for the Advancement of Science, Kappa Mu Epsilon, Board of Trustees and the Executive Committee of Furman University, and Vice President of the Association of Governors' Board of Universities and Colleges. A prolific writer, Mr. Rusche has authored and co-authored numerous articles on nuclear energy.

Born in Yazoo City, Mississippi, Mr. Rusche is married and has three children.

June 1984

SUBCOMMITTEE RECESS

Senator JOHNSTON. With that, we will recess until 10 a.m. tomorrow.

[Whereupon, at 4:42 p.m. Wednesday, April 22, the subcommittee was recessed to reconvene at 10 a.m. Thursday, April 23.]

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 1988

THURSDAY, APRIL 23, 1987

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 10:07 a.m. in room SD–116, Dirken Senate Office Building, Hon. J. Bennett Johnston (chairman) presiding.

Present: Senators Johnston, Sasser, and McClure.

DEPARTMENT OF ENERGY

ATOMIC ENERGY DEFENSE ACTIVITIES

STATEMENT OF SYLVESTER R. FOLEY, JR., ASSISTANT SECRETARY FOR DEFENSE PROGRAMS, DEPARTMENT OF ENERGY

Senator JOHNSTON. Good morning, gentlemen, the hearing will come to order. The subcommittee will continue our review of the fiscal year 1988 budget on the Atomic Energy Defense Activities of the Department of Energy.

And welcome to the committee, Adm. Sylvester R. Foley, Jr., Assistant Secretary of Energy for Defense Programs; and Lt. Gen. James A. Abrahamson, U.S. Air Force, Director of the Strategic Defense Initiative Organization.

We have already discussed the Nuclear Testing Program and Nuclear Materials Production issues, and we will focus this morning on Weapons Research and Development activities of DOE.

Admiral Foley, we will first hear from you. Your statement, of course, will be put in the record, so please proceed as you will.

PREPARED STATEMENTS

Mr. FOLEY. Thank you very much. It is always a pleasure to be here. I appreciate my statement being included in the record, and I would like to include my Deputy Assistant Secretaries statements also for the record. I will proceed with some viewgraphs and lead into the follow-on testimony of Dr. Barker and General Abrahamson.

[The statements follow:]

STATEMENT OF S.R. FOLEY, JR.

INTRODUCTION

Mr. Chairman and Members of the Committee, I am pleased to appear before you in support of the Department of Energy's (DOE) Atomic Energy Defense Activities appropriation requests of $8.1 billion for FY 1988 and $8.5 billion for FY 1989. These requests include $612 million and $648 million respectively, for the Naval Reactor program which is managed by Admiral McKee.

The two-year appropriation request is a step forward and complements our ongoing effort to further stabilize effective long-term program planning. I believe it will ultimately result in better management of our defense activities. This testimony focuses on FY 1988 program requirements. These requirements were developed during a lengthy program and budget decision process which concluded only after extensive management participation throughout the entire Defense Programs complex. The FY 1989 requirements are a logical follow-on to FY 1988 in meeting our mission. It will be necessary to further refine our FY 1989 request, however, as FY 1988 program and budget decisions evolve.

DEFENSE PROGRAMS MISSION

For the Department of Energy and Secretary Herrington, I am responsible for three broad missions. First and foremost is our mission to support the national security policies of the United States for an effective nuclear deterrent. A variety of programs are incorporated in that envelope; developing and maintaining a superior research, development, and testing capability; producing and maintaining parts and nuclear materials for the weapons that make up our nuclear stockpile; processing waste generated from those efforts; and assisting other agencies in determining our adversaries' capabilities and compliance with treaties through verification and arms control activities.

Overlaying our primary mission are two other mission areas. First, we must assure that all of our facilities, materials, technology, and information are as safe and secured as possible. We routinely test our complex on an independent basis to verify its ability to withstand credible security threats.

Second, we have a major commitment to assure that all of our efforts function in a safe, healthful, and environmentally acceptable manner. Our expanding programs in this area will assure that Defense Programs activities function to acceptable standards in the future while redressing past deficiencies.

To support effective operation of the DOE nuclear weapons complex while meeting security and environmental responsibilities, I have enhanced the outyear program planning process by establishing Five-Year Program Analysis and Strategic Issues Analysis processes. These initiatives will help us to identify program activities of long-range strategic importance and balance, and rescope, or eliminate those programs of lower priority thereby assuring the efficient use of limited resources. During this first year of the process, senior managers at headquarters, field offices, and the weapons laboratories are collectively reviewing the status and scope of our activities to ensure that current and future program decisions are compatible with realistic workload projections and applications for our developing technologies. This is an evolving process and will lead to an integrated program plan for the future.

CHALLENGES AND PROBLEMS

The challenges and problems we face are significant. Many are calling for a nuclear testing moratorium, yet continued nuclear testing is absolutely essential to maintain our Nation's existing nuclear deterrent, verify future nuclear weapons applications, and evaluate the feasibility of the

Nuclear Directed Energy Weapons (NDEW) concept. Since this time last year, the Chernobyl accident has focused even more attention on the safety of our aging nuclear production complex. Similarly, the fragility of the weapons complex tends to direct public attention to both our existing and potential environmental problems. The Department is resolved to accommodate our critical safety and environmental commitments, while balancing these requirements with competing program priorities.

Even in normal times, balancing competing program priorities is never an easy management assignment; but these are hardly normal times. Today we are faced with a combination of fiscal constraints; growing environment, safety, and health activities that I will address later; "must-do" restoration and maintenance efforts to support current and realistic future national security requirements; continuing production requirements reflected in the President's Nuclear Weapons Stockpile Memorandum; and funding our highest priority research and development activity - the development and testing of the NDEW concept in support of the Strategic Defense Initiative (SDI).

CHANGES IN OUR MANAGEMENT APPROACH

During my first year as Assistant Secretary for Defense Programs, I have become more conscious of the magnitude and scope of these and many other problems and challenges. In the short time I was on board before I testified last year, I was convinced we must change the way we do business. I am continuing to build on the strong consensus already within the Department that today's major program and budget decisions will have to fully involve field and laboratory management. Our Five-Year Program Analysis and Strategic Issues Analysis processes have achieved this coordinated approach for program planning purposes. As a result of these changes, the field role in the budget process has now been extended from the initial developer of the budget, to full partners in the final decisionmaking process.

We are also working closely with the Department of Defense (DOD) and are jointly developing realistic priorities and achieving a consensus on our short- and long-range plans and goals. A large part of our success is due to the effective implementation of the recommendations of the Blue Ribbon Task Group on Nuclear Weapons Program Management (BRTG). I note that we are seeing significant changes in processes and the philosophical approaches to the early phases of nuclear weapons development. We are participating earlier in the budget process through our input to the DOD Program Objective Memorandum, by providing weapons decision costs for better systems decisions, and working to better balance DOE facilities and capabilities with DOD requirements.

In a similar fashion, the procedures and rules being jointly issued by DOE and DOD for the Nuclear Weapons Council are consistent with the spirit and intent of the BRTG recommendations. These procedures recognize that the nuclear weapons enterprise is a fully integrated process requiring budget integration and coordinated issue resolution.

These changes in our management processes have enabled us to prepare an authorization request that makes some tough choices among very competitive program activities. This has resulted in a balance of DOD needs with DOE capabilities in a restrained resource environment.

FUNDING REQUEST

Our program activities are carried out in a large and very complex network of production and laboratory facilities spread across the Nation. I have a very capable management and support staff in headquarters and in the field to direct the operation of this vast complex. Together, we are responsible for assuring that the nuclear weapons complex has sufficient operational capacity and capability to support national defense objectives.

The total budget request to support these activities will:

- Continue our active effort to restore, revitalize, and properly maintain aging DOE facilities;
- Provide a balanced and vigorous research, development, and testing program;

- Continue our commitment to meet critical environment, safety, and health, and essential safeguards and security needs;

- Ensure progress in our effort to safely store and dispose of radioactive and hazardous wastes;

- Meet the weapons production and nuclear material requirements in the President's Nuclear Weapons Stockpile Memorandum; and

- Provide program growth for our highest priority research and development effort - Nuclear Directed Energy Weapons.

CHART 1. We are requesting an appropriation for Defense Programs of $7.4 billion in FY 1988 and $7.8 billion in FY 1989. This allows approximately 3% real growth over these two years. This growth goes principally to construction projects to maintain, restore, and revitalize the nuclear weapons complex, to our SDI efforts, waste management activities, and includes increases to meet our essential environmental and safety commitments.

Weapons Research, Development, and Testing

In the Weapons Research, Development, and Testing (RD&T) program, we will continue our efforts to maintain a strong technology research and development base. Virtually all of the growth in research and development in FY 1988 supports determination of the technical feasibility of Nuclear Directed Energy Weapons concepts. Our commitment to support the national laboratories will continue with increases provided to sustain the weapons laboratory and testing facilities revitalization initiative. The nuclear weapons stockpile must continue to be reliable and effective. That can only be done by continuing essential underground nuclear tests. There are increases in the budget to provide testing to maintain a strong research and development technical base, modernize and validate the reliability of our weapons stockpile, and to support NDEW.

The FY 1988 budget integrates the Weapons Core program, Nuclear Directed Energy Weapons, and Inertial Fusion research and development as subcategories under Weapons Research and Development to recognize the synergism of these activities. By establishing subcategories, this change is consistent with the need to report separately to Congress our SDI and Inertial Fusion programs. A similar change has been made to the weapons testing where the core program and NDEW are subcategories as well. However, in a practical sense, these activities are mutually supportive and should be managed as an integrated RD&T program.

Production

Essential new weapons deliveries can be made to meet the weapons production requirements directed by the President's annual Nuclear Weapons Stockpile Memorandum. In FY 1988, six different weapons systems will be delivered and modifications made to one other. These requirements were the result of joint DOE/DOD assessments of DOE capabilities and DOD requirements.

We are strongly committed to continuing the long-term priority effort to maintain and modernize our production plants. This vast complex of aging production facilities and assembly plants is faced with severe production pressures trying to meet operational schedules. Increases in this budget support the goal of our restoration and maintenance program. We must ensure our facilities have the capability and capacity to meet production schedules, and in doing so, operate in a safe and effective manner.

Our FY 1988 request also ensures continued availability of nuclear materials in the near-term. It will provide for adequate nuclear materials to produce weapons during the first five years of the Nuclear Weapons Stockpile Memorandum. However, we are concerned about our long-term ability to produce nuclear material. Accordingly, we are studying nuclear material supply options to meet our defense needs. A decision on our need for additional reactor capacity will be made in the near future. The request before you does not provide for new capacity at this time.

Defense Waste

We continue to support the aggressive effort to safely store and dispose of radioactive and hazardous wastes. Increases in FY 1988 will allow the continued transition from a storage mode of operations to preparation of waste for final disposal and ensure that the Defense Waste Processing Facility at the Savannah River Plant and the Waste Isolation Pilot Plant near Carlsbad, New Mexico, become operational in the FY 1989-1990 time period. This will allow completion of critical first elements of our Defense Waste Management Plan. We also are beginning to address the next phase of the plan by submitting a request for a high-level waste immobilization facility for the Hanford Reservation.

Eventually, defense high-level waste is to be disposed of in the geologic repository being developed under the Nuclear Waste Policy Act. We have not identified funds in the budget for the fee associated with this disposal. A Federal Register notice has been issued that addresses various methods of calculating the fee for defense waste. We will submit a budget request at the appropriate time pending a final decision on the method, timing, and amount of the fee.

Security Affairs

Finally, we have improved the Department's safeguards and security posture. The safeguards and security research and development program has played an important role in this accomplishment. Our request includes increases for this program to continue developing measures to ensure adequate protection of the DOE's nuclear weapons, nuclear materials, facilities, and classified information against terrorism, theft, and compromise. Our budget request also provides for continued Verification and Control Technology activities with emphasis on the fabrication, demonstration, and deployment of both research and operational verification systems.

ENVIRONMENT, SAFETY, AND HEALTH

That describes the major thrust of our FY 1988 request. I would now like to share with you some of the challenges my managers have encountered in trying to meet environment, safety, and health (ES&H) requirements and still accomplish critical program activities. Their options for tradeoffs are becoming increasingly limited as our overall share of resources continues to drop while their ES&H obligations go up. Not too long ago we faced similar challenges in making our facilities and nuclear materials secure from potential adversaries. We met that challenge, and we are now turning the corner in the safeguards and security area. Our success in that arena, however, was largely accomplished when managers had a wide range of funding options available to them. Today, this flexibility is becoming more limited because of severe budget restraints. As expected, many of our managers have developed innovative ways to increase the leverage of their Federal dollars. Our long-range strategic planning and prioritization efforts will also help.

CHART 2. Consistent with Secretary Herrington's plans to strengthen the Department's ES&H program, we are developing a comprehensive long-range plan for Defense Programs to better define the scope and cost of our existing and potential ES&H problems; but we already know it is going to be an expensive process. For example, we have preliminary estimates that our total ES&H funding level will exceed $800 million in FY 1989 - that is up 41 percent from FY 1986 and represents about 10 percent of our total FY 1989 request. We are considering different approaches to provide the necessary resources for this activity, including establishing a separate budget category to comply with the Comprehensive Environmental, Regulatory, Compensation, and Liability Act.

I can assure you that we will continue to put forth our very best efforts to meet ES&H requirements and still accomplish priority mission objectives. With your help, we will comply with ES&H laws and regulations while meeting national security objectives.

I personally want to thank you for your support over the past year. It has been a significant factor in the successful execution of our responsibilities. With your continued support and leadership, we will continue to provide this Nation with a strong nuclear deterrent capability. I urge the Committee's approval of our request, so we may again work together toward our common objectives. I look forward to working with you and your staff in the coming year, and I will keep the Committee fully and currently informed of our progress. I will be pleased to answer any questions you may have.

Chart 1

DEFENSE PROGRAMS
FY 1988/1989 CONGRESSIONAL REQUEST
(DOLLARS IN MILLIONS)

	FY 86 APPROP	FY 87 APPROP	FY 88 REQUEST	FY 89 REQUEST
WEAPONS ACTIVITIES	$4,177	$4,181	$4,535	$4,606
NUCLEAR MATERIALS PRODUCTION	1,768	1,858	1,882	2,220
DEFENSE WASTE & TRANS. MGMT.	618	672	811	771
SECURITY AFFAIRS	186	194	210	255
DEFENSE PROGRAMS	$6,749	$6,905	$7,438	$7,852
			+7.7%	+5.6%

Chart 2

DEFENSE PROGRAMS ES&H FUNDING CROSSCUT
(DOLLARS IN MILLIONS)

	FY 1986	FY 1987	FY 1988	FY 1989
OPERATING EXPENSE	$449.0	$507.0	$547.0	$569.0
CAPITAL EQUIPMENT	34.0	39.0	37.0	52.0
CONSTRUCTION	89.2	119.5	155.9	186.0
TOTAL	$572.2	$665.5	$739.9	$807.0
ENVIR. COMPLIANCE & PROTECTION	316.2	371.5	432.9	471.0
HEALTH & SAFETY	256.0	294.0	307.0	336.0
TOTAL	$572.2	$665.5	$739.9	$807.0

Statement of James W. Culpepper

Mr. Chairman, members of the committee, it is a pleasure to appear before you to testify in support of the Department of Energy's Atomic Energy Defense Activities Authorization request for fiscal years 1988 and 1989.

1. INTRODUCTION

MISSION OF THE NUCLEAR WEAPONS PROGRAM

The mission of the nuclear weapons program is to provide the Nation with a credible nuclear deterrent. This involves maintaining and modernizing the nuclear weapons stockpile and nurturing a strong nuclear weapons research, development, and testing program, which includes support for the President's Strategic Defense Initiative. Not only must we understand the feasibility and effectiveness of nuclear directed energy weapon concepts for our own applications, but for our own applications, but we must also understand how an adversary may use them against a United States retaliatory deterrent force or defensive system.

The theme that I would like to stress throughout my testimony is the national importance of the programs which must be managed in an efficient, effective manner while fully taking into account environment, safety, and health, as well as safeguards and security considerations. I would like to emphasize that the nuclear weapons activities are a major part of the Department's budget and as such receive commensurate attention and support throughout the Department. However, this critical national security program represents less than two percent of the Nation's overall defense budget.

I intend to discuss four subject areas: the resources we have to accomplish the program goals; some past and current year accomplishments; our FY 1988-FY 1989 budget requests; and, finally, some special items of concern to me as the acting director of the nuclear weapons program.

RESOURCES

To accomplish the program mission, we need a balanced combination of highly experienced and qualified scientists, engineers and technicians, coupled with specialized equipment and facilities. People at the national laboratories are the primary resource. The Department of Energy laboratories have had good success in attracting and retaining highly qualified people to perform this invaluable work.

A few years ago, a distinguished group of scientists selected the "100 Brightest Scientists in America Under 40" for Science Digest. Of the 100, 11 worked at the three weapons laboratories and another ten worked at other Department of Energy laboratories, giving the Department of Energy 21 percent of the total. Only two worked at other government laboratories.

This standard of excellence continues to be maintained at the laboratories. In 1986, Research and Development magazine identified the 100 most significant technological accomplishments throughout the world. The three DOE weapons laboratories had a total of 12 of the 100 awards. This is another indicator of the quality of the researchers, innovators, and developers at the weapons laboratories.

To maintain a credible deterrent, we must continually update the stockpile to meet needs imposed by a changing Soviet threat and target set. Improvements in our weapons spring from a technology base in such diverse fields as fission and fusion physics, shock hydrodynamics, chemistry and physics of high explosives, electronics, and many subfields of materials science and technology. These fields are explored in light of expressed needs for improved nuclear weapons and to avoid technological surprise, with investigation both in the experimental laboratory and underground testing site. Computation, diagnostic capabilities, and analysis go hand-in-hand with experimentation, and all are necessary for progress.

Expansion of computer capability is one measure of growth of our technology base. Since 1950, computation capabilities have increased by a factor of nearly 100,000. This increase actually represents developments in commercial computer technology and specialized codes developed for use in the weapons laboratories Indeed, the needs of weapons technology have actually driven the development of supercomputers. Our advanced computers facilitate experiment modelling and analyses for the underground test program to ensure that our weapons are reliable and assist us in exploring advanced concepts to avoid technological surprise. I should emphasize that computers are not, and probably never will be, a substitute for underground testing.

Just as supercomputers are important to the weapons laboratories, computer integrated manufacturing is important to the weapons production complex. Computer integrated manufacturing is systems integration encompassing all activities from the planning and design of products through manufacturing and shipping. In recent years, a transition has been made from the manual performance of operations to the use of computers to enhance design, planning, and manufacturing capabilities.

We are pleased with the implementation of the computer integrated manufacturing in the nuclear weapons production complex. We are proud to report that one of our contractors, Martin Marietta, the operator of the Y-12 Plant, has been recognized for its computer integrated manufacturing implementation efforts. Martin Marietta was the 1986 recipient of the "Leadership and Excellence in the Application and Development of CIM Award" of the Society of Manufacturing Engineers. This award is made in recognition of outstanding achievements in implementing computer integrated manufacturing technologies.

With respect to experimental facilities as a resource, many of the nuclear weapons program facilities have unique capabilities not found anywhere else in the country and, in some cases, in the world. For example, the High Explosives Applications Facility which is currently under construction, will

be one of the most sophisticated high explosives research facilities in the world. High explosive performance is a vital part of the functioning of nuclear weapons. The Particle Beam Fusion Accelerator-II Facility--a multimegajoule, light-ion accelerator--is the only existing device that may have the potential of igniting thermonuclear fuel in the laboratory. Finally, NOVA, the world's largest and most powerful laser, provides unique capabilities for experiments in fusion, weapons physics, and areas of plasma and atomic physics. All of these facilities are essential to the maintenance of our technology base.

These resources were obtained as a result of your invaluable support over the years. Your continued support is needed to assure that the resources are sufficient to maintain a vital and robust nuclear deterrent. We have made a conscientious effort to balance the need between manpower, equipment, and existing facilities with the need for new capabilities. Our current planning for the future provides a "level-of-effort" funding for construction which addresses the highest priority facilities.

2. PAST ACCOMPLISHMENTS

Before I present the FY 1988-1989 Weapons Activities program requests, I would like to highlight last year's weapons program accomplishments.

WEAPONS PRODUCTION AND SURVEILLANCE

In fiscal year 1986, the Department of Energy weapons production complex completed all of the required production milestones. Deleted Deleted new warheads were produced and delivered to the Department of Defense for deployment. We completed production of the W79 8-inch artillery-fired atomic projectile and the W85 Pershing II warhead; we continued production on the B61 tactical bomb system, the B83 strategic bomb, the W76 Trident I warhead, the W80-1 sea- and W-80-0 air-launched cruise missile warheads, and the W84 ground-launched cruise missile warheads; and accomplished initial production of the W87 Peacekeeper warhead system which led to an initial operational capability for this extremely important system in December of

1986. The introduction of the W87 Peacekeeper warhead system (Chart 1) into the war reserve stockpile was, we believe, a particularly noteworthy achievement which exemplifies the finest cooperation among the Department of Energy laboratories, production facilities, and the Department of Defense in executing a fast-track warhead development program designed to meet a critical national defense need. Two new warheads progressed on schedule in the production engineering phase of development, the W88 Trident II warhead and the W82 155mm artillery-fired atomic projectile for which production will be initiated in FY 1989 *Deleted* respectively. In FY 1986, considerable effort was also devoted to the upgrade of the reliability and safety of the existing stockpile with the completion of the B28 retrofit program and the continuation of the B61-1 and W31 warhead upgrade programs. Study efforts were also initiated with the Department of Defense to improve the command and control features of the W33 8-inch artillery-fired atomic projectile and to upgrade or replace the W50 Pershing 1a warhead. We, in the Department of Energy, continue to believe that an investment in continued stockpile reliability and safety is absolutely essential to our mission.

In FY 1987, we expect to complete *Deleted* transition two additional warheads into the design engineering phase of development--the Small Intercontinental Ballistic Missile warhead and the Short Range Attack Missile II warhead. The other warhead systems, mentioned earlier, will continue in production.

A cost-saving effort underway within the weapons production complex is the Plutonium Utilization Improvement Program instituted at the Rocky Flats Plant. Plutonium machining and foundry operations result in the production of plutonium oxide which must be reprocessed in order to recover valuable plutonium. The Plutonium Utilitization Improvement Program implements procedures which are expected to reduce by approximately 50 percent the amount of plutonium oxide generation. This program has required minimal capital investment to upgrade equipment in the plutonium foundry; however, it has resulted in the following benefits:

- o over $20 million in cost savings in recovery operations, and
- o increases in the amount of plutonium available for production.

WEAPONS RESEARCH, DEVELOPMENT, AND TESTING

CORE PROGRAM

The weapons research, development, and testing core program encompasses the traditional nuclear weapons research, development, and testing necessary for the nuclear deterrent. Both inertial fusion and nuclear directed energy weapons research are part of the overall nuclear weapons technology base and should be treated as such in allocating weapons research, development, and testing resources to be able to address highest priorities to obtain greatest benefits to the overall weapons research, development, and testing program. In this testimony, each is discussed separately because of specific interests and visibilities.

The first nuclear explosives and all weapons in the present stockpile produce isotopic radiation, blast and heat. Other weapons have been designed to produce tailored effects, e.g., x-rays, neutrons, and electromagnetic pulse. A logical extension of these developments is directed energy and is the primary area of the Department of Energy research in support of the President's Stategic Defense Initiative program.

The core program provides the capabilities necessary to: insure the integrity of the national nuclear weapons stockpile; develop producible weapons for that stockpile; sustain an innovative and future looking technology base for evolving future nuclear weapon capabilities; and to provide the scientific basis for avoiding technological surprise.

In the arena of nuclear weapons research, progress is exemplified by advances in understanding of nuclear explosive processes and effects; computation of criticality safety; electronic developments leading to improved arming, fusing, and firing systems; and ____________________

We have made substantial improvements in electronic components and systems.

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In the field of nuclear weapons development and engineering, we:

- Completed the Short Range Attack Missile II and Small Intercontinental Ballistic Missile Phase 2 feasibility studies and selected the laboratory team to design the weapons for these systems.

- Improved the safety, security, and reliability of nuclear weapons in the national stockpile by implementing new fire safety and use control features.

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Surprises are encountered in some nuclear tests, some are small while others are more dramatic. This is to be expected because nuclear design is empirical, not a textbook science. Most nuclear tests involve unique features which contribute significant data to our base of weapon design knowledge.

Deleted It does clearly illustrate the continuing need to validate computer predictions by nuclear tests at our Nevada Test Site underground laboratory.

NUCLEAR DIRECTED ENERGY WEAPONS

Support for the President's Strategic Defense Initiative program continues to be a major thrust of our research, development, and testing. The reasons for this research were articulated in a joint departmental policy statement signed in 1985:

(1) To determine the feasibility and effectiveness of counterdefensive

nuclear-driven systems that an adversary may develop for use against future United States surveillance and defensive systems.

(2) To understand the technical feasibility and impact that such concepts might have on our deterrent forces if utilized in Soviet defensive systems.

(3) To explore nuclear directed energy options as Strategic Defense Initiative possibilities if needed.

Nuclear Directed Energy Weapons represent a new generation of tailored effects from a nuclear explosion. Nuclear Directed Energy Weapons research is the nuclear portion of the Strategic Defense Initiative program carried out by the Department of Energy. The basic concept is to convert a significant fraction of the immense energy from a nuclear explosion either into energy that is concentrated into intense, precisely directed, narrow beams or into a cluster of very small "pellets." Nuclear directed energy weapons have the potential of increasing the energy incident on distant targets Deleted

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Since we last appeared before this committee, there has been significant progress made by our laboratories in strategic defense research.

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A major study on utilizing laboratory facilities and capabilities was completed to complement the underground test program for the x-ray laser. The study was done to assure maximum benefits (increased data and understanding) to the program for resources expended.

A systems analysis methodology was developed to evaluate Nuclear Directed Energy Weapons concept missions in Strategic Defense Inititative architectures for both adversary threat and United States option applications. Mission analyses were completed for the x-ray laser and similar analyses for other Nuclear Directed Energy Weapons concepts were initiated.

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The Nuclear Directed Energy Weapons program continues to use the creative, efficient, and cost effective strategy of add-on experiments on other non-nuclear directed energy weapons underground nuclear tests

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INERTIAL FUSION

The inertial fusion concept is based on compressing fuel to extremely high density and heating it to the required temperature, so that the fusion fuel ignites and burns before the compressed mass has time to disassemble. An efficient pulsed-power accelerator using light-ion beams to compress fuel has been developed. Construction of the 100-trillion watt Particle Beam Fusion Accelerator (Chart 2) was completed in December 1985 within budget and ahead of schedule. Because of the high efficiency and low cost of pulsed-power technology, the Particle Beam Fusion Accelerator II has enough energy to have the potential of igniting thermonuclear fuel targets. In the first year of operation, we have made substantial progress in characterizing the machine performance. This progress attests to the sound engineering design, our ability to understand and operate the accelerator, and to the future of the Particle Beam Fusion Accelerator II as an important laboratory capability.

Also during FY 1986, NOVA (Chart 3), in its first hohlraum experimental series, reached a new high of the density-time-temperature product needed for fusion ignition. Deleted

ENVIRONMENT, SAFETY AND HEALTH

The Department of Energy has a continuing responsibility for providing a safe workplace for its employees, assuring protection for the health and safety of the public and protecting the environment. In past years this has meant doing as well as the best of private industry. Over the past several years many Federal, state, and local laws have been enacted to protect and rehabilitate the environment. These actions have placed additional requirements on the management and operation of our facilities.

The weapons production complex and the laboratories continued making progress in these areas during the past year. For example, the solar evaporation ponds at the Y-12 Plant, shown full and empty (Charts 4 and 5), were used for percolation and evaporation of high-nitrate contaminated waste and had caused severe chemical contamination to the watershed in the vicinity of the Plant. Their use has now been discontinued. For handling of the closure of these ponds, the Y-12 Plant received an award from the Tennessee Society of Professional Engineers for the "Engineering Accomplishment of the Year." Their function, which was critical to continued operation of the production facilities, is now being handled by the West Tank Farm, the new $5 million Central Pollution Control Facility, and processing facilities at Oak Ridge. A total of 10,330,000 gallons of wastewater was treated and released to East Fork Poplar Creek in accordance with a permit issued under the Clean Water Act. On May 30, 1986, the ponds were considered to be empty, completing the project at least two years earlier than had been projected if other special treatment facilities were used. This new process effectively demonstrates that wastewater containing nitrates and heavy metals in open ponds can be economically treated to meet the water quality criteria.

In response to the Comprehensive Environmental Response, Compensation, and Liability Act the Department initiated assessments to determine the status of its sites and to plan for remedial action. The first phase reports were completed for most sites and released to the appropriate regulatory authorities. As a result of these studies cleanup of 4.5 acres at the Pinellas Plant is underway; the north lagoon and underground tank farm at the Kansas City Plant have been removed from service and are being cleaned up; the Mound Plant has installed an advanced wastewater treatment plant to attain compliance with its National Pollutant Discharge Elimination System permit; and the boundary of the organic solvent contamination plume in the groundwater offsite from the Livermore National Laboratory has been determined. These studies should give us a good start towards meeting the requirements of the Superfund Amendments and Reauthorization Act which was passed by the last Congress.

With respect to nuclear material scattering safety, a FY 1986 Congressionally approved project provides for a structural upgrade of existing plutonium facilities at the Rocky Flats Plant. This project is being accomplished and further reduces the already small offsite radiological risk from the Plant that might arise from an event such as an earthquake or tornado.

SAFEGUARDS AND SECURITY

The increase in malevolent incidents worldwide in recent years has motivated initiatives to improve the overall protective posture of the nuclear weapons complex. During the past year we have continued to make progress in improving the protection of our most critical assets. Our major thrust, to date, has been to upgrade our facilities against the potential outsider threat by employing a variety of new and advanced techniques and physical protection systems to detect and prevent potential malevolent acts.

A major improvement has been the increase in protective force numbers. The protective force regularly undergoes testing to maintain constant readiness. The September 1985, the Department of Energy assessment states that "any adversary who attempts to gain control over or steal a nuclear weapon, a critical weapon component, or special nuclear material would face a high probability of failure." Notwithstanding this conclusion, the Department of Energy recognized the need for a number of actions to further improve the effectiveness and efficiency of the protection program. With actions identified to mitigate the outsider threat to an acceptable level, our emphasis now includes other areas including the development of additional protection systems and strategies to increase the level of confidence against the potential threats posed by an insider.

One result of these programs is that the weapons complex facilities have gone through a comprehensive program of physical security upgrades. Examples of some of the physical security upgrades are depicted on this chart (Chart 6).

3. FY 1988-FY 1989 PROGRAM REQUEST

The Department of Defense Authorization Act, 1986, Public Law 99-145, requires a two-year budget for the Department of Defense and related agencies.

The FY 1988/1989 budget request (Chart 7), which totals $4.5 billion in FY 1988 and $4.6 billion in FY 1989 supports the Nuclear Weapons Stockpile Memorandum and the critical activities of the research and development effort to maintain a credible nuclear deterrent and meet the milestones for a focused Strategic Defense Initiative. This request also reflects the Secretary of Energy's priorities for assuring facilities and materials are secure and safe from potential adversary actions and that environment, safety, and health concerns are identified and corrected in a responsible and cost efficient manner.

The FY 1988/1989 budget request provides for a balance between capacities to produce or improve weapons and the capabilities to design and test them; between people to perform research and facilities to conduct research in and between restoring the current asset base and adding new capabilities. Achieving this balance within available resources is a challenge to our management of the program that we recognize and accept. This chart (Chart 8) depicts our attempts at balancing these elements.

WEAPONS PRODUCTION AND SURVEILLANCE

The Weapons Production and Surveillance program supports the fabrication and assembly of nuclear weapons and weapons components, and stockpile maintenance and reliability assessment. The production and surveillance activities are supported by a nationwide complex of Government-owned, contractor-operated facilities managed by our Albuquerque Operations Office. Our FY 1988/1989 budget request supports the production, stockpile improvement and preproduction activities for a wide range of warhead programs essential to the national defense interest (Chart 9). We have requested $1.9 billion operating expenses in FY 1988, an increase of $98 million representing a real increase of 1.5 percent over FY 1987. The FY 1989 request for operating expenses is $2.0 billion.

Although the total new production in FY 1988 and 1989 is lower in terms of units produced than it has been in recent years, the equivalent workload, in terms of required outlays, continues to increase. Future production levels are projected to increase substantially in the later part of the approval period. The warhead-unit production ebb in FY 1988/1989 is due mainly to the reductions that we absorbed in our FY 1986 budget to comply with the Balanced Budget and Emergency Deficit Control Act of 1985 and, to some degree, due to revised military requirements. In fact, the FY 1988 and FY 1989 production levels, when normalized to the level of effort required due to varying production complexity factors and funding lead-times, are greater than the FY 1987 level (Chart 10). Our FY 1988/1989 budget supports the continuing build of B61-3/4 tactical bombs, the B83 Modern Strategic Bomb, the W80 warhead for the sea-launched and air-launched cruise missiles, the Peacekeeper Intercontinental Ballistic Missile, and the completion of the Ground-Launched Cruise Missile warhead program. In FY 1989, we will also begin quantity production of the W88 warhead for the Trident II system and continue to retrofit the B61 strategic bombs.

Equally important is the fact that in FY 1988 and 1989 we will be pursuing preproduction activities that will pave the way for the introduction of five extremely important warhead or bomb systems in the Deleted These systems include the Short Range Attack Missile II; the Small Intercontinental Ballistic Missile, which is an important part of the strategic missile modernization program; the 155mm Artillery-fired Atomic Projectile; a nuclear depth/strike bomb and, as mentioned earlier, the Trident II system warhead.

These systems not only provide improved operational effectiveness but also continue our efforts to provide a safer and more secure nuclear weapons stockpile. We believe it essential that the Department of Energy's production complex be in a strong position to meet the workload requirements in the 1990's. This cannot be done unless we make the appropriate investments in FY 1988/1989 to procure materials and tooling and accomplish the necessary facility construction and upgrade that are essential to the foreseen demands.

Through the formulation of the Nuclear Weapons Stockpile Memorandum, which the President approved on January 9, 1987, the Departments of Defense and Energy worked closely together to develop a nuclear weapons development and production strategy which will not only meet our envisioned national security needs but is also very realistic in terms of warhead-to-platform delivery schedules and in the projection of future warhead requirements. Our FY 1988/1989 budget request supports the Defense requirements and the resources to assure that the Nation maintains the necessary production capability base to meet future weapons production requirements.

PLUTONIUM RECOVERY AND RECYCLE

An activity of significant importance to the weapons program is the recovery and recycle of plutonium needed for nuclear weapons production. Recovery of plutonium from retired weapons and from manufacturing scrap is an important supply source as the operating reactors cannot provide all of the plutonium needed. Also, it is very economical when compared to meeting requirements through the production of new plutonium in reactors. The Rocky Flats Plant accomplishes most of the plutonium recovery. The New Plutonium Recovery Facility, known as Building 371, completed in 1981 was to have provided the Department of Energy with a replacement facility for the old Rocky Flats plutonium recovery facilities. Unfortunately, there were throughput problems with some of the Building 371 processes, and these processes are not economical to operate.

As General Withers indicated in his statement last year, the Department of Energy has been carefully studying the need, scope, and capacity requirements and options for a possible modification of Building 371 at the Rocky Flats Plant to correct deficiencies in its plutonium processing capabilities and to assure that sufficient plutonium is available for weapons production. We believe that existing older facilities will be able to supply plutonium in the interim period until replacement facilities are available. However, the processing capacity of these facilities is declining, and there is some concern for their continued availability in the near term.

In preparation for a possible Building 371 modification project, research, development, demonstration, and design activities are being undertaken. The purpose of these efforts is to clearly verify and demonstrate that the processing systems to be installed in the modification project will operate satisfactorily. One of these activities is the Plutonium Recovery Option Verification Exercise which has been underway for several years. The Plutonium Recovery Option Verification Exercise involves an effort to supplement the plutonium recovery technology base, and to verify the design, operability, reliability, and maintainability of the Building 371 modification. In addition, the Plutonium Recovery Option Verification Exercise will verify the decontamination procedures necessary for Building 371 modification; the equipment procurement, installation, and checkout procedures; and the management approach for accomplishing the modification project. The Plutonium Recovery Option Verification is being accomplished using operating funds in the amount of about $29 million over a five year period. The Plutonium Recovery Option Verification demonstration modules will provide a limited supply of plutonium metal. This output will provide some contribution to the supply of plutonium in a period in which all sources are important.

WEAPONS RESEARCH, DEVELOPMENT, AND TESTING

The FY 1988 request of $1.7 billion for weapons research, development, and testing operating expenses as shown in this chart (Chart 11) will enable the

Department to pursue the traditional core program which I will explain in detail as well as nuclear directed energy weapons research and inertial fusion research activities.

CORE PROGRAM

The core program (Chart 12) which currently represents over two-thirds of the technical research and development manpower, is composed of two major elements: the technology base and the weapons development, engineering, and certification efforts.

The success of the Department of Energy in carrying out its mission to provide a credible nuclear deterrent relies directly on the depth and breath of its technology base. There is no industrial or academic counterpart to these capabilities elsewhere in the United States and, if lost or degraded, they cannot be replaced or restored easily or quickly. This capability has been an essential element of our nuclear deterrent for the past 40 years.

There are a number of major focal areas which drive the technology base research:

- Weapon Safety: Minimize further the possibility of accidental detonation of high explosives, accidental nuclear yield, or accidental scatter of radioactive materials.

- Weapon Use Control: The capability to prevent unauthorized use of nuclear weapons.

- Efficient Packaging: Package devices of given yields into smaller sizes and/or less weight.

- Tailored Effects: Tailor weapon outputs for enhanced military effectiveness and/or reduced undesired effects.

- Weapon Understanding: Understand better the physical processes which occur inside and outside a nuclear device when it explodes.

- Related Basic and Applied Research: Exploratory work in basic and applied physics, chemistry, materials, and engineering to support the long range development of weapon technology.

The weapons development, engineering, and certification provides stockpile maintenance on a continuing basis and, in the near term, stockpile modernization. For stockpile maintenance we continue to monitor the safety, security, and reliability of those nuclear weapons in the stockpile. For example, in connection with the Stockpile Evaluation Program, each year samples of each type of weapon are taken from the stockpile for extensive inspections and component testing. Through these activities, problems have been discovered which have led to design changes and retrofits.

Many existing systems have remained in the stockpile longer than originally anticipated, exceeding their original design lifetimes. These weapons are reviewed annually with the Department of Defense, studying whether changes in weapons design and operational procedures are warranted to improve nuclear safety, security, or use control. For example, both the Nike Hercules warheads (W31) and B28 bombs are being improved with *Deleted* Also, some of the B61 bombs are being upgraded with insensitive high explosives. In addition, we are working on a new design for the Short Range Attack Missile that will improve performance and safety (use of insensitive high explosives). We will continue to evaluate other systems to ensure their safety, security, and reliability.

Stockpile modernization also includes developing new weapons in response to new threats to our security.

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Another requirement is the warhead for the Small Intercontinental Ballistic Missile which complements the Peacekeeper program. The Small Intercontinental Ballistic Missile warhead will be a modified version of the Peacekeeper warhead, Deleted

Deleted The mobile Small Intercontinental Ballistic Missile system is in response to the increased threat of Soviet weapon systems to our fixed-site deterrents such as the Minuteman weapon system.

NUCLEAR DIRECTED ENERGY WEAPONS

The FY 1988 request provides for a significant increase in our research, development, and testing activities dedicated to support the President's Strategic Defense Initiative (Chart 13). Accelerated strategic defense research is necessary to meet our immediate objective of understanding the potential Soviet capability to design and deploy nuclear directed energy weapons that would put the United States retaliatory force or a future defensive system at risk, i.e., through technological "surprise." This information is needed as soon as possible because of the potential impact it could have on current nonnuclear strategic defensive initiative research and planning.

Nuclear directed energy weapons are also being researched as United States strategic defense options. For the United States, nuclear directed energy weapons research is an especially attractive option for it permits us to exploit the advantages of high technology, an area of United States superiority. This provides us with the potential for offsetting the military advantages gained in recent years by the Soviet Union.

We believe the Soviets have been conducting strategic defense research for some time. Soviet work may have gone beyond laboratory research and experimentation in some cases. The Soviet Union has the world's only operational antiballistic missile system and a limited operational anti-satellite system.

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The Nuclear Directed Energy Weapons research initiated by the Department of Energy laboratories is part of their assigned mission to understand potential applications for advanced nuclear weapons technologies. These Nuclear Directed Energy Weapons concepts were under study as a fundamental part of our research efforts well before the 1983 announcement of the Strategic Defense Initiative. From the beginning, however, it was recognized that directed-energy nuclear weapons, if feasible, would find their most important applications in strategic defense. This new technology may make it possible to attack reentry vehicles at much greater distances than previously considered possible. Moreover, and of still greater potential importance, the technology of directed-energy nuclear weapons could introduce entirely new defensive options.

The Department of Energy is conducting research on four Nuclear Directed Energy Weapons concepts: Deleted

Deleted / Looking to the future, FY 1988 will be a critical year for our strategic defense research efforts.

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/ We will need to sustain these important activities in FY 1989 and beyond if we are to meet the Strategic Defense Initiative milestones.

INERTIAL FUSION

The objective of the Inertial Fusion Program since its inception in the 1960's has been to determine if it is possible to ignite small masses of thermonuclear fuel in the laboratory for potential military and commercial applications. The motivation was creation of a capability to study fusion physics in the laboratory setting through the use of powerful laser and

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The program objective leads to a laboratory fusion capability which would make significant contributions to the development of nuclear weapons, to the study of some aspects of nuclear vulnerability and effects, and to the fundamental understanding and demonstration of many other applications of inertial fusion technology. The National Academy of Sciences panel chaired by Dr. William Happer asked the representatives of the laboratory weapons program, Deleted Deleted to address the questions of the level of fusion yield that would represent a significant step forward in laboratory capabilities. From this dialogue was developed the target of 1000 megajoules (1/4 ton explosive equivalent yield) as the level at which a broad range of scientifically important results could be obtained Deleted Deleted Definition of the technical requirements for such a capability is the specific program goal articulated in the current Inertial Fusion Program plan. However, it should be noted that we do not believe a laboratory fusion capability can provide the totality of experience required to support the weapons development and stockpile maintenance responsibilities of the Department of Energy.

The objective of the near term program is to develop the physics and technology base required to project high gain performance with confidence, as well as to define the technology requirements and cost basis for construction of an affordable high gain fusion capability.

The near term program makes an additional important contribution to the weapons program by providing training in the skills of weapon designers and engineers in such critical areas as the various processes of functioning nuclear weapons, material science, nuclear diagnostics, Deleted Deleted and high energy density sources such as lasers and particle beam accelerators. The inertial fusion technical base has also proven valuable for concept definition and testing in several areas of directed energy weapons research.

The physics and technology data bases required for the near-term goal will be addressed through three complementary efforts which will be supported in the FY 1988 budget request. The FY 1988 funding request as depicted in this chart (Chart 14) is reduced from the FY 1987 level due to higher program priorities.

(1) High gain target physics and demonstration of target fabrication technologies Deleted

(2) Target-driver interaction and hydrodynamics research with existing laboratory drivers, including research on scaled versions of high gain targets.

Deleted

(3) Driver technology development aimed at demonstrating the cost and technology requirements for a multi-megajoule laboratory microfusion facility.

NUCLEAR EMERGENCY SEARCH TEAM

The Nuclear Emergency Search Team represents the Department of Energy response to the need for a national capability which can effectively counter an attempt by terrorists or extortionists to achieve their objectives by utilizing stolen nuclear weapons, improvised nuclear devices, or radioactive disperal devices. The Nuclear Emergency Search Team mission includes providing scientific and technical capabilities as depicted in this chart (Chart 15), support for nuclear threat credibility assessment, search and detection of radioactive sources, gaining physical access to a suspect device, device diagnostics and disablement, collateral damage limitation, and nuclear effects prediction.

This capability has been under development and refinement for almost a decade. The Nuclear Emergency Search Team concept has been tested extensively during exercise situations and the search capability has been utilized in several actual incidents. The mission and operational responsibilities of Nuclear Emergency Search Team are based on the provisions of the Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974, as amended; the

Department of Energy Organization Act of 1977, Executive Orders (including Executive Order 11490, Executive Order 11953, and Executive Order 12333) and National Security Decision Directives,

Deleted The overall Federal response capability to nuclear terrorism events is a national resource and the product of cooperation between several United States Government agencies. In addition to various resources of the Department of Energy, predominantly Nuclear Emergency Search Team, the Department of Defense, the Federal Bureau of Investigation, and the Nuclear Regulatory Commission contribute significant expertise and manpower to maintain the overall capability.

Should a nuclear threat occur or is suspected to be developing, a cognizant government organization (such as the Federal Bureau of Investigation) would request that a threat credibility assessment be made by the Department of Energy. If the assessment evaluated the threat as credible, the Federal Bureau of Investigation would request appropriate Nuclear Emergency Search Team assistance from the Department of Energy. Appropriate Nuclear Emergency Search Team resources would be deployed under the direction of the Nevada Operations Office.

We have continued to develop and refine the Department of Energy capabilities and personnel through the use of drills and multi-agency exercises. During the last year three major Nuclear Emergency Search Team exercises were conducted to assure ourselves that we are prepared to meet various crises situations.

PROGRAM DIRECTION

This activity (Chart 16) provides for the Federal program direction oversight of the weapons program and community assistance at Los Alamos, New Mexico. Overall employment will increase by 9 full time-equivalents to 857 in FY 1988. This provides the required Federal employees for the Albuquerque and Nevada Operations Offices as well as for Headquarters.

Also provided under Program Direction are the needed contractual services. These services cover such items as security, janitorial, health, printing and reproduction, and technical assistance.

PLANT & CAPITAL EQUIPMENT

We are requesting $863 million for plant and capital equipment in FY 1988, of which $546 million will be for construction of facilities. Five new projects are to support programmatic requirements. Two new construction projects are related to upgrading the physical security of our plants, and four new projects are related to environmental, safety, and health statutory or regulatory requirements.

PROGRAMMATIC CONSTRUCTION PROJECTS

The FY 1988 budget request includes $262 million for construction projects directly related to supporting our programmatic mission of designing, developing, and producing nuclear weapons.

PRODUCTION AND SURVEILLANCE

As presented in these charts (Chart 17 and 17A), $41.9 million of this amount is included for initiating construction of three new projects in FY 1988, Small Intercontinental Ballistic Missile, High Explosive Machining and Facilities Capability Assurance Program.

Funding of $20.0 million is required in FY 1988 to begin facility design, engineering and upgrades of the Small Intercontinental Ballistic Missile Warhead Production Facilities. The High Explosive Machining Facility at the Pantex Plant is needed to provide assurance for the continued and uninterrupted production of nuclear weapon. Machined high explosives parts are essential major components of all nuclear weapons produced at the Pantex Plant. The high explosive components are required to initiate a nuclear reaction in a weapon. The capability and capacity to machine these high explosive components are unique to Pantex; there are no commercial sources from which to obtain them. Pending the completion of the new High Explosive Machining Facility the existing facility will be operated utilizing revised personnel administrative controls relative to the exclusion area on the east and west ends of the current high explosive machining building.

The Facilities Capability Assurance Program is an FY 1988 initiative of the nuclear weapons production complex to manage actively capital resources to arrest and prevent the continuing deterioration of its aging facilities. The Facilities Capability Assurance Program is intended to be an ongoing program specifically designed to identify, manage, and correct long-term facilities deficiencies within a specified annual funding ceiling. The Facilities Capability Assurance Program addresses long-term solutions for utility capacity and capability problems and problems of poor and inadequate buildings and other real property improvements reaching the end of their useful life expectancies.

The production complex consists of more than 14.5 million square feet of buildings with over 70 miles of roads and 171 miles of fencing on more than 20,000 acres of land having a total estimated value in excess of $8.3 billion excluding capital equipment. More than 55 percent of the facilities (structures, real property improvements, special facilities, and utilities) were constructed in the 1940's and 1950's. Many of these facilities have reached or exceeded their reasonable life expectancy, are in poor condition, and/or are functionally inadequate to meet modern weapons production requirements.

An overall "investment strategy" is required to assure that the capabilities to meet the production complex's national security mission is not impaired as these facilities suffer the wear and tear of continued utilization. The deterioration problem was first identified in the Restoration Program which addressed production equipment and utilities.

The appraisals conducted as part of the Restoration Program identified many deficiencies that were beyond the limited scope of that program.

The Facilities Capability Assurance Program utilizes a documented, audible appraisal program to identify poor physical conditions, functional inadequacy, and capacity and capability problems of facilities and utilities to meet current production complex program requirements.

RESEARCH, DEVELOPMENT, AND TESTING

The nuclear weapons research, development, and testing process requires highly specialized facilities to achieve programmatic goals. A decade of decline in the 1970's of advanced research, development, and testing effort and minimal construction funding for the weapons research, development, and testing complex created a backlog of critically needed facilities to replace aged facilities and to provide facilities which meet the technological need and standards for the mission needs of the 1980's and beyond. The research, development, and testing research complex covers almost 18 million square feet of facilities with an estimated replacement value of $7 billion. Many of these facilities were constructed in the 1950's creating a current need for replacement and refurbishment. As indicated in my next chart (Charts 18 and 18A) $39.0 million is requested to initiate construction of two new projects in FY 1988.

The Special Nuclear Materials Research and Development Laboratory Replacement at the Los Alamos National Laboratory will replace and refurbish aging laboratories that are 33 years old. The project is critical to maintaining the Laboratory's plutonium processing facility operations and support to the nuclear weapons complex. This project will allow the Department of Energy to continue long-term, safe, and secure operations of essential chemistry and metallurgy research and development services in support of plutonium processing facility operations. The present Chemistry and Metallurgy Facility will be almost 40 years old when the replacement facility is completed. We will continue to operate the present facility in a safe and reliable manner;

however, if replacement efforts are not started, a potential situation could arise forcing the closure of the present building and supporting systems. If the present facilities were shutdown, plutonium operations would essentially come to a halt at the Los Alamos National Laboratory effecting research, development, testing, and production programs.

There is a potentially serious situation in the current chemistry and metallurgy laboratory and support systems that could adversely effect the safety of personnel and that would require shutting down the laboratory. If the laboratory was shutdown, operations and research and development at the plutonium facility would essentially come to a halt and test program objectives and other commitments to the national defense programs would not be met.

The remaining programmatic construction projects directly relate to maintaining the basic research, development and testing capability. The new starts included within the Revitalization project, an initiative started in FY 1984, provides for the construction of new facilities; modifications, relocations, and additions to existing facilities. They will provide new research capabilities at the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, and the Sandia National Laboratories to meet the research, development, and engineering needs of the future, and new essential support facilities for the weapons testing activities at the Nevada Test Site. The purpose of this ongoing programmatic effort of revitalization is to ensure an research, development, and testing complex with the technological capabilities and supporting facilities to meet the research, development, and testing mission requirements.

ENVIRONMENT, SAFETY, AND HEALTH

The Department maintains a continuing responsibility for the protection of the health and safety of its personnel, its contractors' employees and the general public. Emphasis is placed on radiological protection throughout the nuclear weapons program, with renewed emphasis placed on addressing potential nonradiological hazards to the environment and to public and employee health and safety which were not recognized even a decade ago. This renewed emphasis responds to the increasing requirement resulting from Federal, state, and local laws and regulations. Within the Department of Energy, from the Secretary down to program line managers, responsibility and accountability for implementing environmental, safety, and health activities are emphasized.

I am requesting funding for specific line item construction projects which are needed to meet state or Federal requirements. Failure to fund these projects may result in a failure to meet compliance orders and other state/Federal action and could result in litigation and the potential for shutdown of the particular facilities.

A summary of the $47.9 million of construction funding requested for environment, safety, and health activities is given in Charts 19 and 19A. The five new starts in FY 1988 are required to address compliance issues, including: initiation of cleanup of offsite groundwater contaminated with organic solvents which have migrated from spills and waste disposal leakage at the Lawrence Livermore National Laboratory; correction of the sanitary sewage collection and treatment system problems at Los Alamos National Laboratory to meet Clean Water Act requirements; provide seismic upgrade to Building 111 at Lawrence Livermore National Laboratory to meet the current life safety goal of the Uniform Building Code; provide fire protection upgrades for several critical facilities in the weapons complex; and, provide personnel radiation monitoring laboratories at several locations in the complex so that dosimetry programs will meet the performance criteria set out in the Department's Laboratory Accreditation Program. Continuation of six prior-year projects is required in responding to previously identified protection and compliance issues.

Additional environment, safety, and health protection and compliance issues will be addressed through requested operating funds. This includes such items as salaries for staff dedicated to environment, safety and health activities, personnel protective equipment, general orientation training of all personnel and special training for specific staff, environmental monitoring and surveillance costs, health clinics, and fire protection equipment and personnel.

SAFEGUARDS AND SECURITY CONSTRUCTION

We have been systematically enhancing the protection of the weapon complex in recognition of the need to continue to improve, refine, and upgrade our operations in this area to meet the defined threat to our vital assets. As a result, our facilities have gone through a comprehensive program of significant physical security upgrades in the recent past and we are continuing with that program.

The FY 1988 request of $76.2 million (Charts 20 and 20A) includes $9.2 million for the initiation of two new construction projects, one at the Los Alamos National Laboratory in New Mexico and the other at the Pantex Plant in Amarillo, Texas. The balance of the FY 1988 authorization request continues seven prior-year construction projects at various weapons complex sites.

The $109.7M Safeguards and Security Upgrade Project at the Pantex Plant

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The $15.3M Safeguards and Security Upgrade, Phase II Project, at Los Alamos

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The protection program needs these upgrades to assist us in defeating the defined threat to the Los Alamos National Laboratory.

These projects address identified vulnerabilities that continue to exist at both these sites. We must continue to take timely actions to correct identified vulnerabilities and to pursue better ways to improve the effectiveness of our protection programs and plant operations.

4. CONCERNS

UNDERGROUND NUCLEAR TESTING

The United States relies on the credibility of its nuclear forces as the foundation of its policy of deterrence. The United States must maintain an effective, survivable, and varied nuclear force to convince any adversary that we could retaliate decisively in the event of aggression against us or our allies. A ban on nuclear testing would do serious damage to the credibility of the deterrent and thus, endanger world peace and stability. President Reagan summarized the United States position on banning nuclear tests in a letter to the Allies on March 14, 1986:

> "A comprehensive test ban remains a long term objective of the United States. We believe such a ban must be viewed in the context of a time when we do not need to depend on nuclear deterrence to ensure international security and stability and when we have achieved broad, deep, and verifiable arms reductions, substantially improved verification capabilities, expanded confidence-building measures, and greater balance of conventional forces."

A nuclear test ban would eliminate our ability to perform confidence tests of the current nuclear stockpile. This would prevent detection and/or correction of possible stockpile problems of the future. Had it not been for nuclear testing in the past, many problems would have gone undetected and our confidence in the capabilities of these weapons would have been an illusion. Nuclear tests are also necessary to verify that any fixes made to deteriorating or faulty weapons are effective (Charts 21, 22, 23).-

Under a test ban, new developments required to maintain the credibility of our deterrent into the future in the face of the changing Soviet threat could not be pursued.

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Remember that delivery systems and their associated nuclear weapons are often made obsolete by nonnuclear developments that the Soviets will pursue regardless of nuclear testing, for example, improvements in air defenses, submarine detection, hardening, dispersal of forces, mobility, etc. Incorporation of many of the most modern nuclear weapon safety and security measures would not be possible under a nuclear test ban. The nuclear weapons in the stockpile are as safe as it was possible to make them when they were produced. However, if improvements can be made, we should not have to compromise because of an inability to certify performance. A critical aspect of future technology involves the development of nuclear directed energy weapons. Exploration of most Nuclear Directed Energy Weapons concepts involving nuclear explosives will not be possible under a test ban. Assessment of United States vulnerabilities to Soviet directed energy weapons of these types (which may already exist) will be precluded, as well. In fact, all testing to assess the vulnerability to nuclear weapon effects of United States military systems such as missiles, aircraft, radars, surveillance satellites, and so on will be severely limited by a halt to nuclear testing.

Without the ability to do satisfactory experiments, the small number of top-level weapons scientists that we currently have would leave for other occupations, compounding the difficulties of analyzing and correcting future stockpile problems. Cost savings will be virtually non-existent. The nuclear design laboratories, the test site, and most of their facilities (and associated costs) will still have to be maintained.

Some have considered reducing the current 150 kiloton threshold, but this would be a mistake. Today, this threshold restricts us from conducting full-yield tests of many of our most important strategic nuclear weapons. Reducing the threshold further would, in addition, restrict us from testing critical components of most weapons to verify their performance, for example,

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Because of this country's reliance on a nuclear defense, it is often stated or assumed that it is the most expensive form of defense and that the quantity and total explosive yield of our nuclear weapons stockpile has increased steadily. In reality, the cost of maintaining a strong nuclear deterrent, along with the necessary, associated nuclear testing, is substantially cheaper than the cost of increasing our conventional forces to be on par with the Soviets and their allies. *Deleted* the United States stockpile, while incorporating numerous technological improvements is near its lowest numerical level in more than 20 years. Our total explosive megatonnage has likewise been reduced by *Deleted* since 1960.

CONTINUING NEED FOR NUCLEAR WEAPON RESEARCH

We see a continuing need for an active nuclear weapons research, development, and testing program in order to maintain United States deterrence. To maintain the credibility of our deterrent, new nuclear weapons need to be developed to address these emerging threats.

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The Soviets are going to mobile missile launchers and mobile command posts, thereby reducing our ability to hold them at risk. Present systems cannot effectively attack these. In addition, further deployment of a Soviet ABM system will demand new weapons to effectively attack them. Similarly, other new threats which are not adequately addressed at present will continue to emerge.

Continuing the United States developments of the past two decades, we see a strong continuing trend to develop safer, more secure systems. This need is especially heightened with the increasing terrorist presence around the world. More secure designs are possible but may demand new nuclear system designs. Also as Soviet capabilities develop to counter our weapon systems, new advanced systems will be required to assure weapon system survivability. For example, weapons to be deployed on stealth vehicles may have special demands in size and shape.

Another important reason for continued research and development efforts is to avoid technological surprise. It is important to be aware of what is possible in nuclear weapon design to avoid being caught at a fatal disadvantage due to technological developments by an adversary. It is also vital to ensure that we do not get surprised by unexpected material behavior as our own weapons age in the stockpile.

BLUE RIBBON TASK GROUP

I would now like to discuss our actions taken during the past year in support of the recommendations provided by the Blue Ribbon Task Group on Nuclear Weapons Program Management. Rather than cover each recommendation in detail, I will defer that to the March 1 report required by the Congress in the FY 1987 Defense Authorization Act and instead highlight some of the activities in support of three major themes of particular interest to this committee--increased cost consciousness, improved cost management, and more effective interface with the Department of Defense.

I firmly believe that the intent of the Blue Ribbon Task Group in the area of increased cost consciousness is being met by the Department of Energy and the various joint Department of Defense/Department of Energy working groups. The past year saw significant changes in processes and the philosophical approach to the early phases of nuclear weapons development, directly leading to heightened cost consciousness and restoration of a more balanced relationship among cost and other factors in defining military requirements and the Department of Energy warhead design options.

The Department of Energy is aggressively questioning the validity and resource implication of military characteristics being requested by the Services. Cost information is being gathered on those requirements that drive design characteristics so that valid and timely tradeoffs of costs and benefits can be performed. Where costs are judged to outweigh benefits, military characteristics are being reconsidered and changed as appropriate to allow for lower cost warhead designs.

There are several recent examples of the newly emerged importance of warhead costs. In the case of the Air Force's Short-Range Attack Missile II, early decision cost estimates were developed for 13 design candidates prior to warhead design and design team selection by the Department of Energy. This is the first time that significant cost datum was available for consideration before a weapon system entered Phase 2a, the design definition and costing phase. This allowed the Department of Energy to make a better-informed selection decision, conserve scarce research and development funds, and get an early start on design engineering work. It should also be noted that the Air Force made substantial changes to its requirements on the weapon due to the Department of Energy cost factors. The final selection of the baseline design for the Navy's Nuclear Depth/Strike Bomb will not be made until cost data are gathered for a wide variety of requirement and design options. Already several important changes have been made to the requirements and the design characteristics to reduce costs.

I must emphasize again that we are not compromising fundamental and well-defined warhead requirements, but rather assigning cost an appropriate priority in the decision equation.

Tied in closely with increased cost consciousness at all levels of management are our activities to improve internal cost management systems and external cost reporting. Most of the work on improving internal cost management is being performed by the Department of Energy's Albuquerque Operations Office in conjunction with the production plants and weapon laboratories. The basic thrust is to develop a system for establishing a baseline management cost for each weapon system and to monitor that cost through production. We are currently defining baseline cost management concepts, publishing cost management policy for the weapons complex, and restructuring weapons program schedule and cost-tracking systems to provide timely cost reporting and status information. In addition to weapon system cost management, AL is working to improve indirect cost management policies and procedures. Finally, cost management has been introduced as a factor in the award fee process for our contractors.

The major initiative in the area of external cost reporting has been the Nuclear Weapons Acquisition Report. The initial report was provided to the Congress last March and, I believe, was well received. It provides the reader with more meaningful explanations of program status, costs, and factors contributing to cost changes. Perhaps of more importance for cost management is its value as the common definitional basis upon which decision costs for tradeoff purposes will be expressed and the baseline cost for a weapon system will be structured. I believe that this responds to one of the fundamental concerns expressed by the Blue Ribbon Task Group.

In terms of our interface with the Department of Defense, I have already mentioned several positive changes in the day-to-day working relationship. At Headquarters, we are emphasizing a more proactive interface with the Department of Defense in three major arenas--the Defense Resources Board, Joint Requirements Management Board, and the newly established Nuclear Weapons Council. Last summer, as part of the FY 1988 budget review process, we provided a Program Objective Memorandum-like document to the Defense Resources Board. This document identified decision costs by weapon system for the five-year Defense program period and highlighted several issues of relevance to both Departments. We also reviewed and provided comments on issue papers affecting the Department of Energy nuclear weapons requirements. We are invited to attend Joint Requirements Management Board meetings as an observer when those meetings pertain to nuclear systems.

Finally, the Nuclear Weapons Council which held its first meeting earlier this month offers much promise as a high-level focal point for those major issues of joint concern to both Departments. The Secretary of Energy has designated the Assistant Secretary of Defense Programs to represent the Department on this council. Although the responsibilities and membership of the Nuclear Weapons Council were identified in the FY 1987 Defense Authorization Act, we are actively working with the Department of Defense to define a supporting structure to maximize the effectiveness of the Nuclear Weapons Council itself.

Finally, I would like to assure this committee that all levels of the Department of Energy management are firmly committed to the purpose and intent of the Blue Ribbon Task Group recommendations. Our actions have been positive, and aggressive. Tangible benefits have already been realized. We will continue to pursue this matter diligently.

SUMMARY

In summary (Chart 24), our request, if sustained, fully supports the Presidentially approved Nuclear Weapons Stockpile Memorandum as well as the President's Strategic Defense Initiative program. Inertial Fusion is integrated into the weapons research, development, and testing and continues support for the non-Department of Energy laboratories. Funding is provided for an austere continuation of the restoration and revitalization efforts. Provision is also made for those activities and projects necessary to comply with statutory environmental, safety, and health requirements and to enhance security throughout the weapons complex.

We are making substantial progress on the nuclear weapons program objective of assuring peace through a nuclear deterrent. We thank you for your support in the past and seek your support of the funding request before you.

In closing, I would like to thank you for your strong support through the years and for the opportunity to appear before you today.

PEACEKEEPER

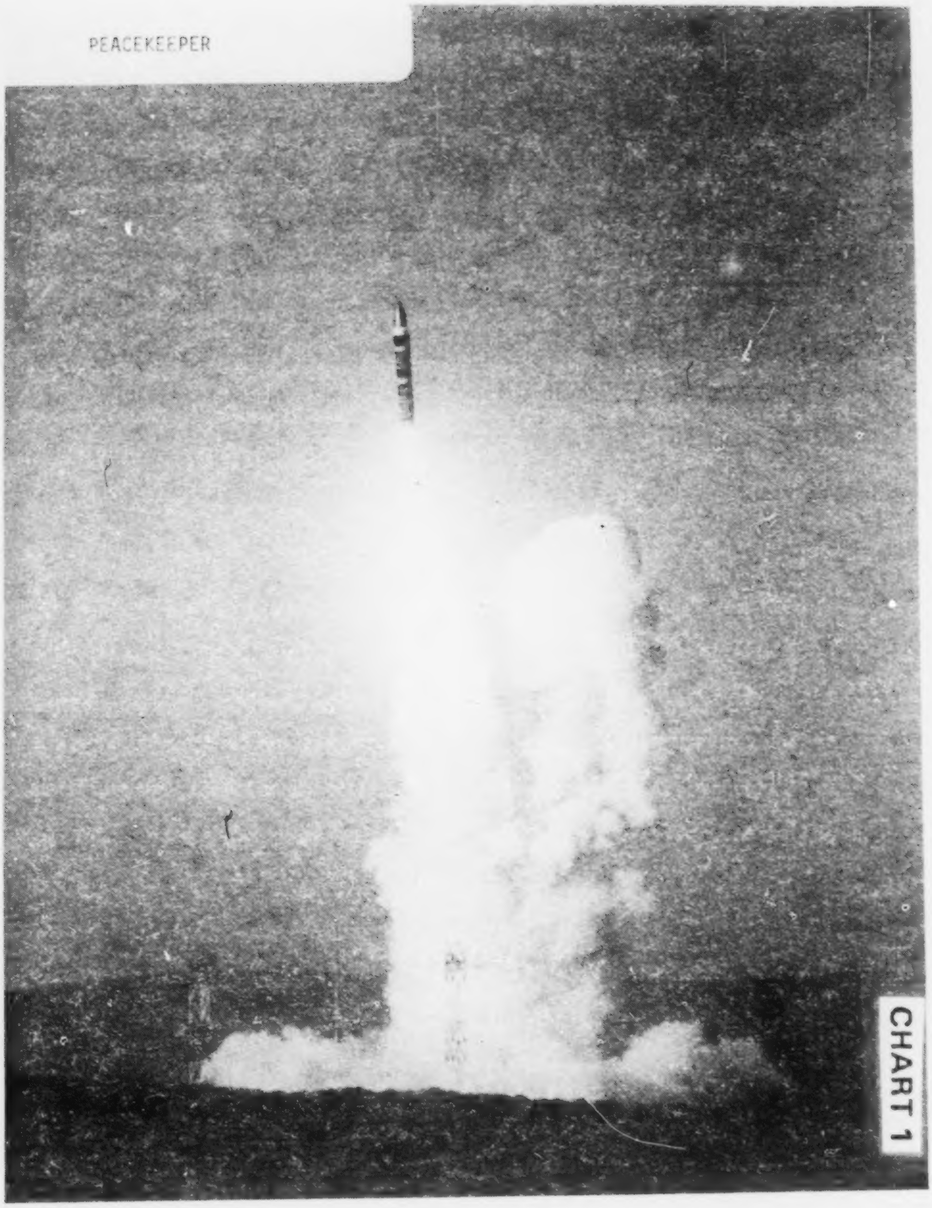
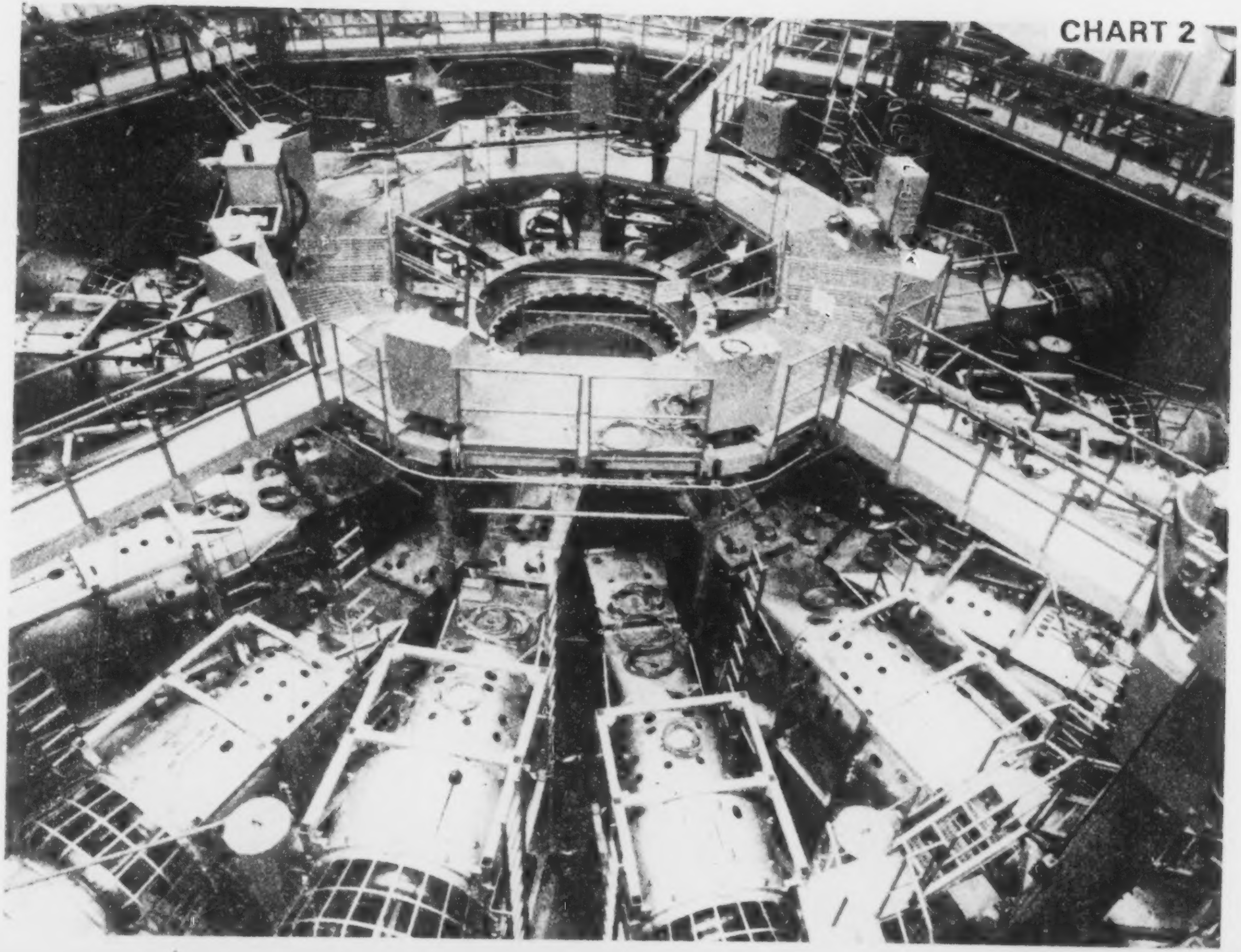


CHART 1

CHART 2



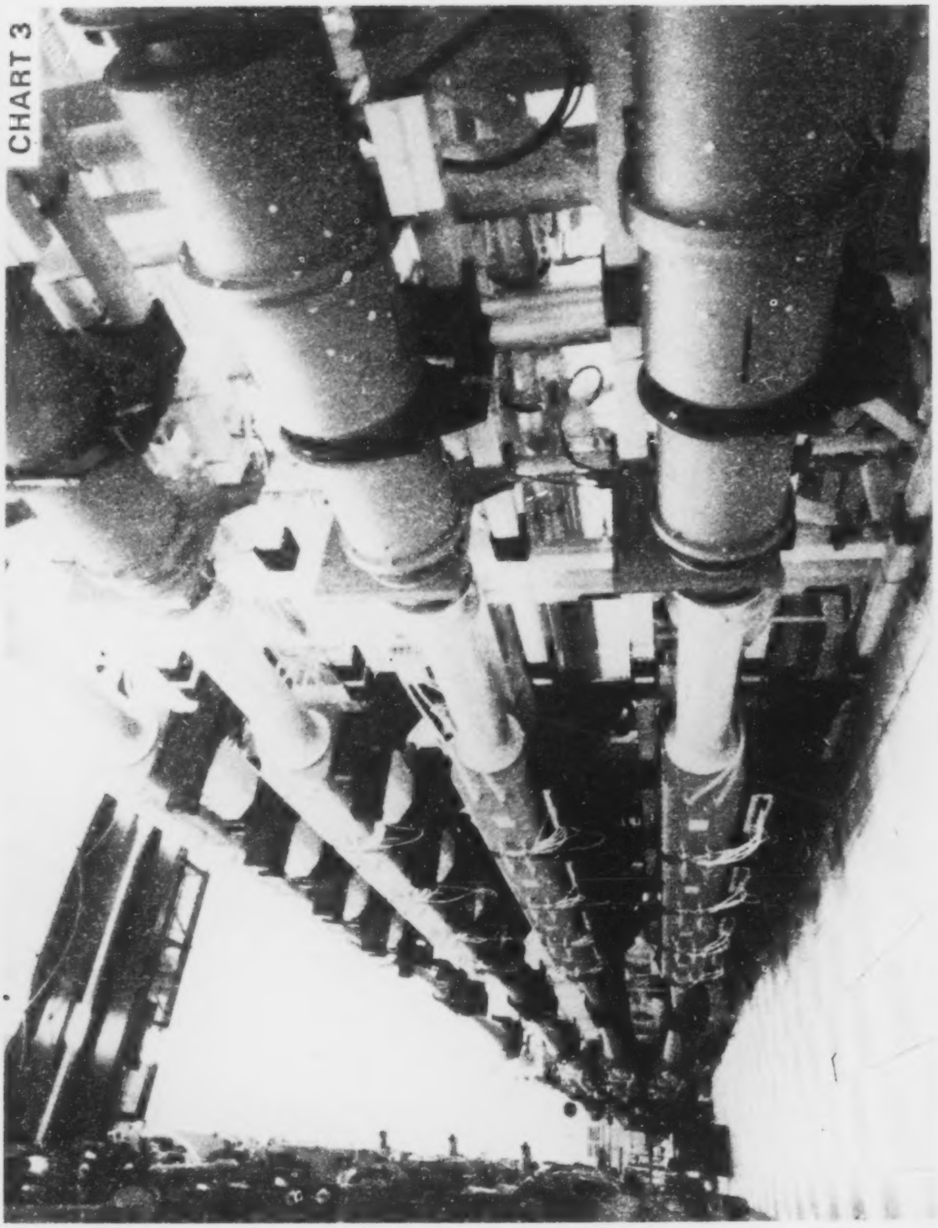


CHART 3

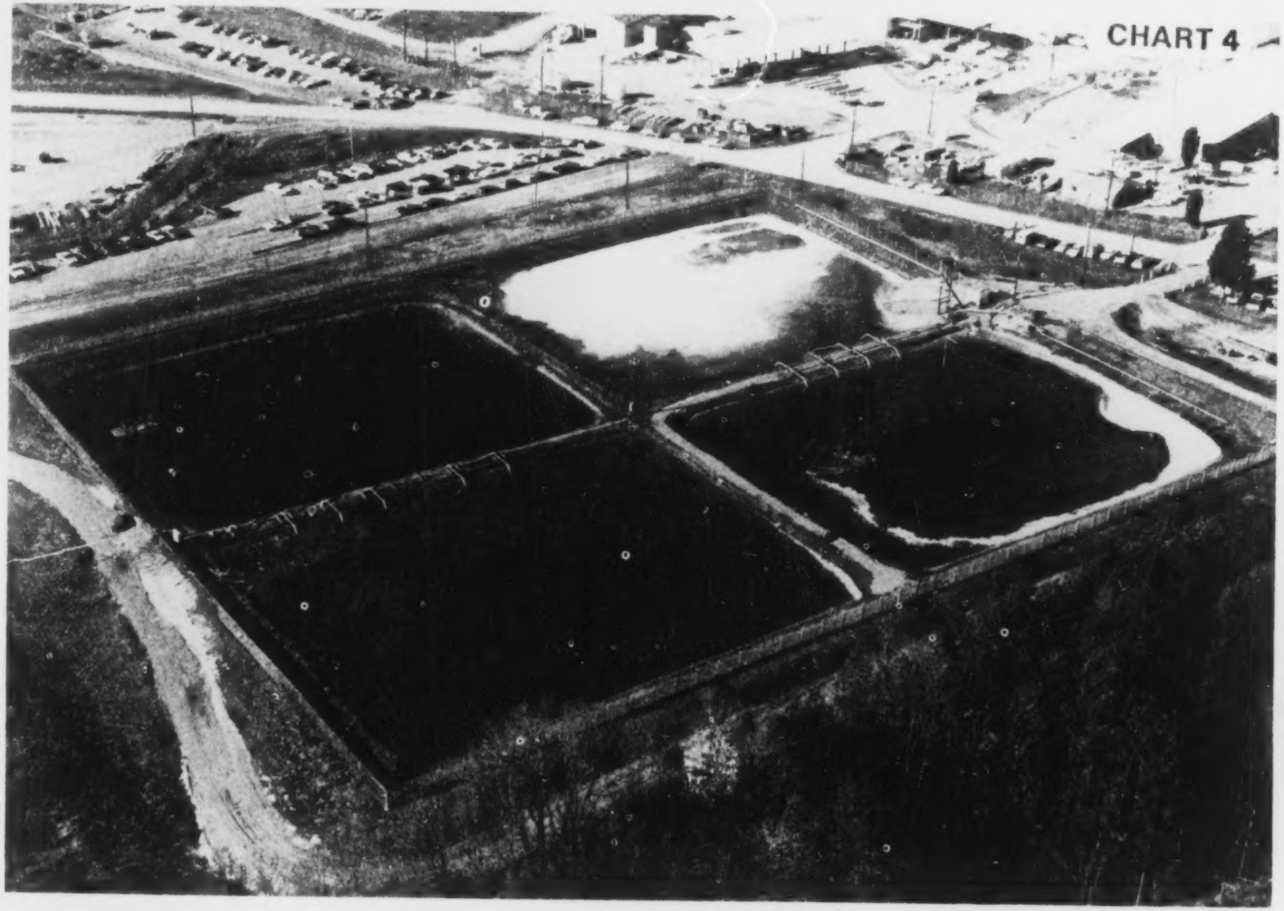


CHART 4

CHART 5

CHART 6 DELETED

CHART 7

WEAPONS ACTIVITIES
(DOLLARS IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
RESEARCH AND DEVELOPMENT (R&D)				
OPERATING	$ 961.7	$1,011.1	$1,101.7	$1,087.4
CAPITAL EQUIPMENT	101.2	101.3	123.0	127.9
CONSTRUCTION	135.6	118.2	172.8	195.8
TOTAL R&D	1,198.5	1,230.6	1,397.5	1,411.1
TESTING				
OPERATING	522.4	532.9	583.9	560.0
CAPITAL EQUIPMENT	45.0	59.5	64.6	67.1
CONSTRUCTION	21.4	27.3	41.5	29.7
TOTAL TESTING	588.8	619.7	690.0	656.8
PRODUCTION AND SURVEILLANCE (P&S)				
OPERATING	1,741.3	1,813.3	1,911.3	2,035.9
CAPITAL EQUIPMENT	125.3	127.0	129.6	134.6
CONSTRUCTION	420.8	320.8	331.5	290.0
TOTAL P&S	2,287.4	2,261.1	2,372.4	2,460.5
PROGRAM DIRECTION				
OPERATING	102.7	69.8	74.8	77.8
TOTAL WEAPONS ACTIVITIES	$4,177.4	$4,181.2	$4,534.7	$4,606.2

CHART 8

BALANCED PROGRAM

- PEOPLE AND FACILITIES
- DESIGN CAPABILITIES
- PRODUCTION CAPACITIES
- RESTORE/MAINTAIN ASSET BASE
- ADD NEW CAPABILITIES
- PROTECT COMPLEX AND ENVIRONMENT

CHART 9

SECRET/RD

WEAPONS SYSTEMS IN PRODUCTION

- B61-3 BOMB
- B61-4 BOMB
- W80-0 SEA LAUNCHED CRUISE MISSILE WARHEAD
- W80-1 AIR LAUNCHED CRUISE MISSILE WARHEAD
- B83 MODERN STRATEGIC BOMB
- W84 GROUND LAUNCHED CRUISE MISSILE WARHEAD
- W87 PEACEKEEPER MISSILE WARHEAD
- W88 TRIDENT II WARHEAD

STOCKPILE IMPROVEMENT PROGRAM

- B61-1 BOMB CONVERSION TO B61-7 BOMB

PREPRODUCTION

- SHORT RANGE ATTACK MISSILE II
- SMALL INTERCONTINENTAL BALLISTIC MISSILE
- 155MM AFTILLERY-FIRED ATOMIC PROJECTILE
- NUCLEAR DEPTH/STRIKE BOMB

CHART 10 DELETED

CHART 11

RESEARCH, DEVELOPMENT, AND TESTING - OPERATING EXPENSES
(DOLLARS IN MILLIONS)

	FY 1986 ACTUALS	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
CORE PROGRAM	$1,102.4	$1,131.2	$1,156.5	$1,201.9
NUCLEAR-DIRECTED ENERGY WEAPONS	243.8	270.0	416.6	328.7
INERTIAL FUSION	137.9	142.7	112.5	116.8
SUBTOTAL RD&T	$1,484.1	$1,543.9	$1,685.6	$1,647.4

CHART 12

RESEARCH, DEVELOPMENT, AND TESTING - CORE PROGRAM
(DOLLARS IN MILLIONS)

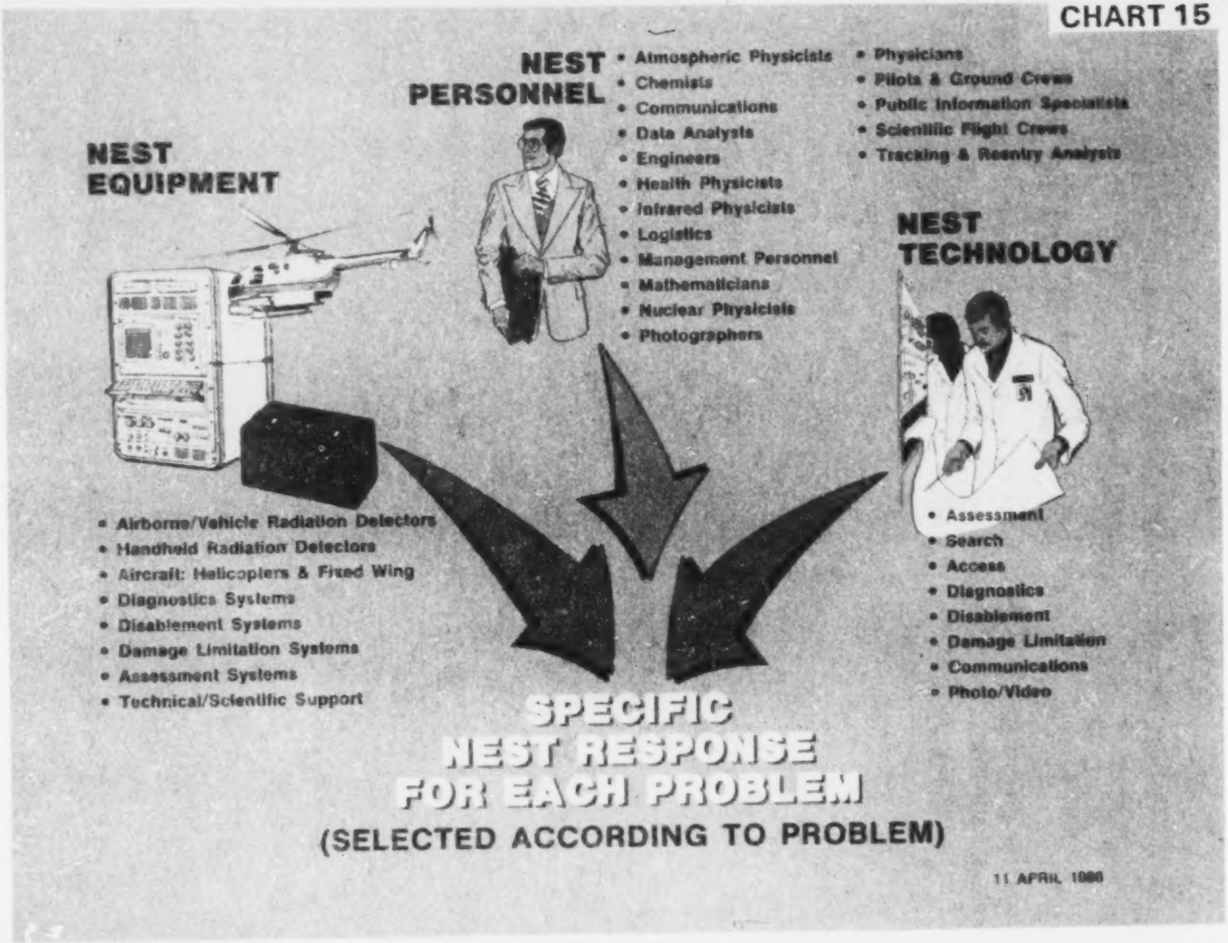
	FY 1986 ACTUAL	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$1,102.4	$1,131.2	$1,156.5	$1,201.9
CAPITAL EQUIPMENT	115.4	119.8	139.6	144.9
CONSTRUCTION	155.0	130.7	192.3	207.9
TOTAL, CORE PROGRAM	$1,372.8	$1,381.7	$1,488.4	$1,554.7

CHART 13

RESEARCH, DEVELOPMENT, AND TESTING - INERTIAL FUSION
(DOLLARS IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$ 137.9	$ 142.7	$ 112.5	$ 116.8
CAPITAL EQUIPMENT	9.5	8.9	6.0	6.1
TOTAL, INERTIAL FUSION	$ 147.4	$ 151.6	$ 118.5	$ 122.9

CHART 15



NEST EQUIPMENT

- Airborne/Vehicle Radiation Detectors
- Handheld Radiation Detectors
- Aircraft: Helicopters & Fixed Wing
- Diagnostics Systems
- Disablement Systems
- Damage Limitation Systems
- Assessment Systems
- Technical/Scientific Support

NEST PERSONNEL

- Atmospheric Physicists
- Chemists
- Communications
- Data Analysts
- Engineers
- Health Physicists
- Infrared Physicists
- Logistics
- Management Personnel
- Mathematicians
- Nuclear Physicists
- Photographers
- Physicians
- Pilots & Ground Crews
- Public Information Specialists
- Scientific Flight Crews
- Tracking & Reentry Analysts

NEST TECHNOLOGY

- Assessment
- Search
- Access
- Diagnostics
- Disablement
- Damage Limitation
- Communications
- Photo/Video

SPECIFIC NEST RESPONSE FOR EACH PROBLEM

(SELECTED ACCORDING TO PROBLEM)

11 APRIL 1986

CHART 16

PROGRAM DIRECTION
(DOLLARS IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
PROGRAM DIRECTION	$ 102.7	$ 69.8	$ 74.8	$ 77.8

- PROVIDES FOR 857 FEDERAL FTE's ($45.1M)
- PROVIDES FOR NEEDED CONTRACTUAL SERVICES ($21.7M)
- SUPPORTS THE LOS ALAMOS COMMUNITY ASSISTANCE PROGRAM ($8.0M)

CHART 17

PRODUCTION AND SURVEILLANCE - PROGRAMMATIC PROJECTS
(DOLLARS IN MILLIONS)

PROJECTS	TEC	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
88-D-122, FACILITIES CAPABILITY ASSURANCE PROGRAM, VL	$154.1	$ 0	$ 19.2	$127.3
88-D-125, HIGH EXPLOSIVE MACHINING FACILITY, PANTEX	60.0	0	2.7	13.0
88-D-127, SMALL INTERCONTINENTAL BALLISTIC MISSILE (SICBM) WARHEAD PRODUCTION FACILITIES, VL	65.0	0	20.0	17.0
87-D-122, SHORT RANGE ATTACK MISSILE (SRAM II) WARHEAD PRODUCTION FACILITIES, VL	69.5	1.0	37.0	19.2
87-D-123, PROTECTIVE CLOTHING DECONTAMINATION FACILITY, ROCKY FLATS	5.1	0.5	4.6	0
86-D-130, TRITIUM LOADING FACILITY REPLACEMENT, SAVANNAH RIVER	120.0	29.5	46.8	28.0
85-D-112, ENRICHED URANIUM RECOVERY IMPROVEMENTS, Y-12 PLANT	51.0	21.5	12.5	0
85-D-113, POWER PLANT AND STEAM DISTRIBUTION SYSTEM, PANTEX	26.3	5.5	2.0	0
85-D-115, RENOVATE Pu BUILDING UTILITY SYSTEMS, ROCKY FLATS	34.9	14.3	1.1	0
85-D-125, TACTICAL BOMB PRODUCTION FACILITIES, VL	27.1	13.1	0	0
84-D-112, TRIDENT II WARHEAD PRODUCTION FACILITIES, VL	156.1	12.1	3.3	0
82-D-109, 155MM ARTILLERY FIRED ATOMIC PROJECTILE	39.8	9.8	0	0
FY 1989 PROGRAMMATIC	TBD	0	0	20.0
TOTAL - PRODUCTION AND SURVEILLANCE PROJECTS		$ 97.5	$149.2	$224.5

CHART 18

RESEARCH, DEVELOPMENT, AND TESTING - PROGRAMMATIC PROJECTS
(DOLLARS IN MILLIONS)

PROJECT	TEC	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
89-D-XXX, NEW PROJECTS	TBD	$ 0	$ 0	$ 36.2
88-D-105, SPECIAL NUCLEAR MATERIALS R&D LABORATORY REPLACEMENT, LANL	$ 210.0	0	10.0	22.0
88-D-106, REVITALIZATION, PHASE II, VARIOUS LOCATIONS	359.8	0	29.0	80.0
86-D-104, STRATEGIC DEFENSES FACILITY, SNLA ..	70.0	14.8	15.0	3.0
86-D-105, INSTRUMENTATION SYSTEMS LABORATORY, SNLA	19.9	7.3	8.0	1.5
86-D-106, LABORATORY DATA COMMUNICATIONS CENTER, LANL	25.0	11.8	12.2	0
85-D-102, REVITALIZATION, PHASE I, VARIOUS LOCATIONS	$ 152.3	40.0	33.5	5.7
84-D-102, RADIATION-HARDENED INTEGRATED CIRCUIT LABORATORY, SNLA .	47.5	3.0	0	0
84-D-107, TESTING REVITALIZATION, VARIOUS LOCATIONS .	79.2	9.8	5.5	0
82-D-144, SIMULATION TECHNOLOGY LABORATORY, SNLA ..	39.9	5.9	0	0
TOTAL, RD&T PROJECTS		$ 92.6	$ 113.2	$ 148.4

CHART 19

ENVIRONMENT, SAFETY, AND HEALTH (ES&H) PROJECTS
(DOLLARS IN MILLIONS)

PROJECTS	TEC	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
89-D-XXX, NEW CONSTRUCTION STARTS	TBD	$ 0	$ 0	$ 13.6
88-D-102, SANITARY WASTEWATER SYSTEMS, LANL	$ 16.7	0	1.0	7.6
88-D-103, SEISMIC UPGRADE, LLNL	6.8	0	1.1	5.7
88-D-124, FIRE PROTECTION UPGRADE, VL	15.3	0	1.7	6.5
88-D-126, PERSONNEL RADIOLOGICAL MONITORING LABORATORY, VL	6.1	0	1.0	5.1
87-D-102, ENVIRONMENTAL COMPLIANCE AND CLEANUP, LLNL ...	24.7	0	9.0	12.0
87-D-127, ENVIRONMENTAL, SAFETY, AND HEALTH UPGRADE, MOUND	4.1	2.4	1.7	0
86-D-103, DECONTAMINATION AND WASTE TREATMENT FACILITY, LLNL	40.9	5.3	12.0	8.5
86-D-122, STRUCTURAL UPGRADE OF Pu FACILITIES, ROCKY FLATS	$ 5.6	$ 2.6	$ 0.2	$ 0
86-D-123, ENVIRONMENTAL HAZARDS ELIMINATION, VL	38.5	18.0	13.3	0
85-D-121, AIR AND WATER POLLUTION CONTROL, Y-12 PLANT .	29.0	9.8	1.0	0
84-D-124, ENVIRONMENTAL IMPROVEMENTS, Y-12 PLANT	45.4	9.8	5.9	1.4
TOTAL, ES&H CONSTRUCTION		$ 47.9	$ 47.9	$ 60.4

CHART 20

SAFEGUARDS AND SECURITY (S&S) PROJECTS
(DOLLARS IN MILLIONS)

PROJECTS	TEC	FY 1987 APPROPRIATION	FY 1988 REQUEST	FY 1989 REQUEST
88-D-104, SAFEGUARDS AND SECURITY UPGRADES, PHASE II, LANL	$ 15.3	$ 0	$ 3.5	$ 11.6
88-D-123, SECURITY ENHANCEMENTS, PANTEX	109.7	0	5.7	7.5
87-D-104, SAFEGUARDS AND SECURITY ENHANCEMENTS II, LLNL .	28.9	2.0	7.0	10.1
87-D-130, RECEIVING AND SHIPPING FACILITY, PINELLAS	2.7	0.3	2.4	0
86-D-125, SAFEGUARDS AND SITE SECURITY UPGRADE, PHASE II, PANTEX	9.8	6.4	2.0	0
86-D-124, SAFEGUARDS AND SITE SECURITY UPGRADE, PHASE II, MOUND	4.8	3.0	0	0
85-D-103, SAFEGUARDS AND SECURITY ENHANCEMENTS, LLNL/SNLL	36.7	6.8	9.2	0
85-D-105, COMBINED DEVICE ASSEMBLY FACILITY, NTS	$ 69.5	$ 9.8	$ 28.0	$ 21.7
85-D-106, HARDENED ENGINEERING TEST BUILDING, LLNL	3.1	0.4	0.1	0
85-D-123, SAFEGUARDS AND SITE SECURITY UPGRADE, PHASE I, PANTEX	4.8	1.0	0	0
84-D-211, SAFEGUARDS AND SECURITY UPGRADE, Y-12 PLANT ...	68.0	29.5	18.3	0
84-D-212, SAFEGUARDS AND SITE SECURITY UPGRADE, PINELLAS	7.2	1.0	0	0
TOTAL, S&S CONSTRUCTION		$ 60.2	$ 76.2	$ 50.9

CHART 21 DELETED

CHART 22

NUCLEAR TESTING IS NECESSARY FOR CREDIBLE DETERRENT

- ASSURE RELIABILITY OF THE CURRENT NUCLEAR STOCKPILE
- EXPLORE PROMISING NEW CONCEPTS
- DEVELOP, WEAPONIZE, AND CERTIFY NUCLEAR WEAPONS FOR NEW APPLICATIONS
- UNDERSTAND NUCLEAR EXPLOSIVE PROCESSES
- INVESTIGATE THE EFFECTS OF NUCLEAR EXPLOSIONS ON MILITARY SYSTEMS
- AVOID TECHNOLOGICAL SURPRISE

CHART 23 DELETED

CHART 24

SUMMARY

o SUPPORTS REVITALIZATION/FACILITIES CAPABILITY ASSURANCE PROGRAM.

o SUPPORTS THE NUCLEAR WEAPONS STOCKPILE MEMORANDUM.

o SUBSTANTIAL INCREASE IN NUCLEAR DIRECTED ENERGY WEAPONS (NDEW).

o SUPPORTS NEEDED ES&H AND S&S PROJECTS.

STATEMENT OF JOHN L. MEINHARDT

Mr. Chairman and Members of the Committee; I am John Meinhardt, Deputy Assistant Secretary for Nuclear Materials, within the Defense Programs sector of the Department of Energy. It is my pleasure to appear before you to provide testimony regarding the Department's budget request for the Nuclear Materials program in FY 1988 and 1989.

Responsibilities of this position include the production of nuclear materials for the nuclear weapons complex and the management and disposal of nuclear wastes from all of the Department's defense activities. I thank the Committee for the support you have given to these activities, and particularly your support during the recent months as we reviewed the safety of N Reactor in Richland, Washington, in light of the Chernobyl accident, and as we developed our conclusion that C Reactor at the Savannah River Plant would remain shut down.

Nuclear materials production and defense waste management consist of a complex of nuclear production reactors, metal foundries, chemical processing plants and waste facilities that constitute a multi-billion dollar industry unto themselves. It is an industry with both unique hazards and important product requirements, requiring careful consideration of quality assurance and internal regulation. The original technology and facilities for producing nuclear materials were placed in operation quickly in the 1940's to meet immediate military requirements. Most of the current facilities were built in the 1950's and early 1960's to meet similar requirements. These dedicated facilities are the sole source of tritium and plutonium in the United States to meet national Defense nuclear materials requirements.

We, therefore, must always be mindful of maintaining the capability and reliability of these facilities while planning and developing new technologies and facilities to meet the future requirements.

With your support we have continually increased production in the 1980's. We felt that Nuclear Materials Production was back on the road toward reliable operation and sufficient capacities to meet defense requirements. However, we did not anticipate the impacts of the accident at Chernobyl, or the discovery of cracks in the C Reactor tank. The Chernobyl accident has resulted in placing N Reactor in a 6-month standdown in order to accomplish accelerated safety improvements. The cost associated with repairing the C Reactor tank, in conjunction with the age of the facility, has led to the decision to place C Reactor in cold standby. These and other recent events have highlighted just how fragile the nuclear materials production system is.

Fortunately, the requirement for new materials projected in the 1987-1992 Nuclear Weapons Stockpile Memorandum (NWSM) are somewhat reduced from last year's NWSM. However, due to the fragility of the production complex, it is very important to continue our programs of productivity retention and improved facility maintenance. This will enable the program to maintain production capacity and capability. DOE and Congress must continue to work together to find solutions to the problems associated with these aging facilities and the increasingly stringent environmental, safety, and health and safeguards and security requirements. Without these solutions or alternate sources for nuclear materials, the Nation's nuclear defense posture will be in jeopardy.

Within the Defense Waste and Transportation Management (DWTM) program, the Department has made a commitment not to build new high-level waste storage tanks but to provide for major waste immobilization facilities as the appropriate step in moving towards geologic repository disposal. The level of activity in the DWTM program is increasing, requiring additional funding, due to the approaching completion of major facilities and the shift from storage to disposal operations. At the Savannah River Plant, we plan to step up preoperational activities at the Defense Waste Processing Facility (DWPF), which is approximately 50 percent complete. The Waste Isolation Pilot Plant (WIPP), which is approximately 80 percent complete, requires additional funding to complete construction and to meet operational requirements. In FY 1988, we have provided funding for initial design activities on the Hanford Waste Vitrification Plant (HWVP). These facilities are all a part of the Defense Waste Management Plan submitted to Congress in June 1983.

(Chart 1) The Nuclear Materials FY 1988 and 1989 request is $2.69 billion and $2.99 billion, respectively. The FY 1988 amount includes $1.88 billion for Nuclear Materials Production, and $0.81 billion for Defense Waste and Transportation Management. The corresponding request for FY 1989 is $2.22 billion for Nuclear Materials Production and $0.77 billion for Defense Waste and Transportation Management.

NUCLEAR MATERIALS PRODUCTION

INTRODUCTION

Goals

(Chart 2) The principal goal of the Nuclear Materials Production (NMP) program is to provide nuclear materials to meet national defense requirements. In addition, we must maintain current production capability and capacity, and at the same time continue to support essential environmental, safety, and health; and safeguards and security requirements.

Nuclear Materials Requirements

The Nuclear Materials Production budget is primarily based on the requirements for tritium, plutonium, and enriched uranium set forth in the Nuclear Weapons Stockpile Memorandum approved annually by the President. This Memorandum consists of the Nuclear Weapons Stockpile Plan for the current and next 5 fiscal years (FY 1987-1992), and a planning projection for the subsequent 5-year period (FY 1993-1997). The President annually issues a National Security Decision Directive approving the Nuclear Weapons Stockpile Plan and noting the planning projection as a point of departure for future stockpile plans. These forecasts are based on projected military needs as well as DOE's ability to respond to these needs.

In addition to contributing to meeting these weapon requirements the materials production complex must also satisfy the other government and civilian demands for nuclear materials. These total requirements are met from existing inventories, new production in our facilities, and through purchase of uranium enrichment services from the DOE Office of Uranium Enrichment. I will now address the requirements for tritium, plutonium, and enriched uranium.

Tritium

The tritium in the weapons stockpile decays at the rate of about 5.5 percent per year. In order to maintain the effectiveness of these weapons the tritium components are exchanged and recycled. In addition to this recycle work, there are new weapons added to the stockpile that require tritium. (Chart 3) This next chart shows the annual new tritium which must be produced to satisfy all tritium demands, including decay and losses, through FY 1997. It is DOE policy to operate our production reactors to meet this tritium requirement before satisfying the requirements for other reactor products.

(Chart 4) This next chart displays the annual percent of reactor production capacity which must be used to meet these tritium requirements. The remaining capacity is used to produce the plutonium which contributes to the total required inventory of plutonium.

Plutonium

(Chart 5) This next chart shows total amount of plutonium needed to satisfy the projected requirements. The total current weapon inventory and production support pipeline contain Deleted of plutonium. The projected total inventory required through the directive period is and the total through the planning period is also **Deleted** of the plutonium required for building new warheads is obtained by reclaiming and recycling materials from the retired weapons returned by the Department of Defense (DOD) to the DOE. Material requirements which cannot be met from DOD returns or existing DOE inventories must be satisfied by new production.

This chart also shows the total amount of plutonium expected to be available to satisfy the projected requirements. As you can see we expect to meet these requirements based on continued operation of N Reactor. The delta between the upper and lower supply lines on the chart reflect the contribution to the total available plutonium inventory based on continued N Reactor operation.

Highly Enriched Uranium

I also need to mention the supply of highly enriched uranium for U.S. weapons. The U.S. weapons program has operated within its existing inventory of enriched uranium for the last 24 years without having to obtain additional material from the uranium enrichment complex. (Chart 6) This has been accomplished by recycling enriched uranium from retired warheads and using existing excess inventories. Although recycling continues, the current schedules for building and retiring warheads will make it necessary to purchase uranium to meet requirements beginning in FY 1990.

Production Process and Materials Flow

(Chart 7) before I get into the details of our request, I would like to describe the DOE defense nuclear fuel cycle and its associated facilities. The gaseous diffusion plants provide uranium of the proper enrichment levels to the feed material facility at Fernald, Ohio. A facility at Ashtabula, Ohio, extrudes depleted and slightly enriched uranium metal ingots provided by the facility at Fernald. The depleted uranium is returned to the Fernald facility for additional processing prior to shipment to the Savannah River Plant, where it is assembled into targets for use in the reactor. The slightly enriched uranium is shipped directly from the Ashtabula facility to Richland where it is fabricated into fuel elements for the N Reactor.

Uranium fuel is obtained from four sources: (1) slightly enriched and highly enriched uranium recycled from irradiated defense production reactor fuel; (2) highly enriched uranium recovered from spent Navy and research reactor fuel at Idaho and processed into usable form at Oak Ridge; (3) highly enriched uranium stockpiled at the Oak Ridge Y-12 plant; and (4) new slightly enriched uranium obtained from the DOE enrichment plants.

Our Savannah River Plant reactors can produce both plutonium and tritium. For plutonium, the reactors use about 60 percent enriched uranium in the fuel rods to drive the reactors and irradiate depleted uranium target cores to produce plutonium.

The N Reactor at Richland uses slightly enriched uranium to fuel the reactor and produce plutonium. The spent fuel from N Reactor is processed at the Plutonium Uranium Extraction (PUREX) fuel processing plant to recover both the produced plutonium and the remaining uranium.

Idaho receives, stores, and processes fuels principally from Navy propulsion reactors for the recovery of residual enriched uranium. The recovered uranium is used as fuel for the Savannah River reactors.

FY 1988/FY 1989 Budget Request

(Chart 8) Turning now to the FY 1988 budget, we are requesting $1.88 billion in support of Nuclear Materials Production activities. This is approximately a 1 percent increase over FY 1987.

(Chart 9) The next chart shows the major reasons for changes from the FY 1987 appropriation. After adjusting for escalation, the program funding is declining. The only significant growth is for environment, safety, and health activities necessary to ensure future compliance with applicable State and Federal regulations. Addressing the priority need to maintain production facilities of adequate capability and capacity also requires funding over current levels. Because of the need to address these critical environmental and maintenance activities, the Nuclear Materials Production program has had to take a hard critical look at core program activities for ways of economizing or deferring lower priority activities, such as R&D reductions, construction stretch-outs, etc.

(Chart 10) The next chart shows a crosscut of our budget request broken down into important program activities. I will address each in detail.

CORE PROGRAM

Base Activities

(Chart 11) The major component of our request is for base activities. Base activities include current operating facilities that will continue to operate for the production of nuclear materials. Of the request, approximately $1.0 billion is needed to support base activities.

Meeting the objectives of the program requires operation of reactor feed materials facilities at Fernald, Ashtabula, and Oak Ridge; operation of the three Savannah River Plant reactors to produce tritium and high-purity plutonium for blending; operation of the Richland N Reactor to produce weapon-grade plutonium; operation of chemical processing facilities at the Savannah River Plant, Richland, and Idaho; ongoing technology development activities; and operation of utilities and other site support facilities. The program also supports processing of Naval and research and development reactor spent fuel returned to Idaho, recovery and processing of scrap nuclear materials to supplement new production, and other Department, government, and industry requirements.

Savannah River Plant Reactors

(Chart 12) The Savannah River Plant reactors will be operated to produce the necessary tritium and plutonium to support the requirements of the Nuclear Weapons Stockpile Memorandum. In FY 1988 the L, P, and K Reactors will be operated at their capacity; the C Reactor will remain in cold standby due to the unrepaired cracks in the reactor tank. The fuel fabrication facilities will operate on a single shift per day to support these reactors.

N Reactor

(Chart 13) The N Reactor, located near Richland, Washington, has received a great deal of congressional, citizen, and press interest since the accident with one of the Soviet Union's graphite moderated power reactors located near Chernobyl in the Ukraine. Although there are significant differences in design, operation, and safety features between the N Reactor and the Chernobyl (RBMK-1000) reactor, both use graphite for neutron moderation and water for cooling the uranium fuel. These similarities and the heightened interest that resulted from the Chernobyl accident have led to extensive safety investigations that began immediately following the accident and are continuing at the present time. Five of the safety evaluations of N Reactor have been initiated at the direction of the Secretary of Energy and another evaluation has been conducted by the Government Accounting Office.

While the Department of Energy believes that the N Reactor can continue to be operated safely until the early to mid-1990's, the Under Secretary of Energy deemed it advisable to extend the N Reactor scheduled refueling downage to a 6 month standdown so that an accelerated safety enhancement program could be undertaken. This intent was announced publicly on December 12, 1986, and went into effect following completion of irradiation of a plutonium fuel charge on January 7, 1987. At the end of this 6 month period, N Reactor will again operate to provide the weapon-grade plutonium necessary to support mission requirements. Additionally, the Department is planning to issue an Environmental Impact Statement (EIS) on the activities associated with the safety enhancement program and expect to complete the EIS in late FY 1989.

Processing Operations

Processing of the reactor fuel and targets separates the plutonium and tritium into product form for use in nuclear weapons. Processing also includes the purification of scrap plutonium that is unavoidably generated in plutonium processing operations. Plutonium is processed in a vast complex of aging facilities, each of which plays a vital role in materials production. Maintaining and upgrading these facilities for long-term operation while at the same time continuing to meet production requirements is a special challenge. With the continued support of this Committee and with the sharing of similar processing capabilities between the Office of Nuclear Materials Production and DOE's Office of Military Application to our mutual benefit, we have been able to meet materials requirements. Continued upgrading of these processing facilities and preventive maintenance will be required to maintain processing capabilities and to deliver plutonium to our weapons program.

(Chart 14) At Hanford, all plutonium processing operations were suspended on October 8, 1986, to correct some problems in authorization, control, and approval of engineering and maintenance work which contributed to violation of criticality prevention specifications. A new work authorization system has been designed, is being implemented, and all personnel are being trained in its use. PUREX was restarted in mid-February of this year. The Plutonium Reclamation Facility is expected to be restarted in April of this year. The last of the processing facilities, the metal production line, is expected to resume operation in July 1987.

Restoration and Retention

The potential for facility related production curtailments, such as those that have occurred during the past year, has been recognized for some time. Projects were initiated as early as FY 1981 to address the emerging problems of plant aging and marginal capacity.

That foreplanning paid dividends. Thanks to production increases obtained through the L Reactor Upgrade, the Restoration of Production Capabilities, and other early projects; we are able to compensate for the loss of C Reactor and the interruption of operations at Hanford.

The problem of overtaxed, obsolete facilities is, however, not solved. Additional initiatives are required if we are to continue to meet production requirements in the future.

The outyear supply projections that were shown in Chart 5 are based on the timely undertaking of a number of key projects. I would like to discuss these next.

(Chart 15) The Productivity Retention Project is directed at two of our most immediate needs: improved plant operational availability and cost efficiency. The output of many of our facilities is declining due to excess maintenance downtimes. Old, worn-out equipment breaks and requires constantly increasing levels of repair. These repairs halt operations and inhibit production. In the case of nuclear facilities, even a minor breakdown can have a significant impact because of the decontamination that must be performed prior to an actual repair.

Further, more stringent safety and environmental release regulations have come into effect since the plants were originally constructed. These standards are now forcing us to curtail, or even halt operations, and must be dealt with.

The total cost of correcting these deficiencies and improving the efficiency of our principal facilities is estimated to be $550 million. The project has been divided into five separately introduced phases in order to accommodate budget constraints. We are requesting approximately $68.9 million in FY 1988 to continue Phases I and II and initiate Phase III. Approximately $127.9 million in follow-on authorization will be needed in FY 1989.

While the Productivity Retention Project represents a substantial investment, the cost will more than be repaid through outyear savings. Without this project we will have to use high staffing levels and other noncost-effective approaches that will drive up operating budgets.

Our requested funding of $36.4 million for the Idaho Restoration project will allow the continuation of the design work and long-lead equipment procurement activities and the initiation of construction activities for the Idaho Fuel Processing Facility which was initially authorized in FY 1985. This project is required to increase capacity and ensure reliability sufficient to process the scheduled Navy fuel returns. The enriched uranium recovered at Idaho greatly reduces the amount of new highly enriched uranium required for the Savannah River Plant production reactors. A recent reevaluation of this reprocessing has shown it to be economically superior to the permanent storage in a repository of spent Naval reactor cores. The FY 1989 request of $73.7 million will allow the Idaho Restoration program to complete definitive design and begin construction of the facility substructure.

The Facility Restoration project was begun in FY 1981 and is the oldest of our three projects to maintain production capacity. It is now in the latter stages of construction. Over half of the subprojects have already been completed and, as mentioned previously, are contributing to our production output. A total of approximately $19.1 million is requested in FY 1988 and FY 1989 to complete the final subprojects.

Special Isotope Separation (SIS)

(Chart 16) The FY 1988 budget requests $56.0 million to continue research and development on Special Isotope Separation technology as well as the design and engineering associated with the production facility which was initiated in FY 1986. The request will enable testing of prototypic plant laser and separator systems directed toward the demonstration of simultaneous multi-isotope plutonium separations beginning in FY 1988.

In FY 1989, site preparation should be completed and physical construction of the proposed SIS facility is planned to begin. The total estimated cost of the SIS project is $530 million.

Process Facility Modifications

(Chart 17) Our requested funding of $17.0 million will allow the continuation of design and construction activities for the Process Facility Modifications project at Richland. This project will add the capability for processing and recovering plutonium from Fast Flux Test Facility (FFTF) fuel to the existing PUREX fuel processing facility. By 1990, FFTF spent fuel containing plutonium, with a replacement value to Defense Programs | Deleted will be available for processing. Much of this material can be used as feed to the SIS production facility expected to be operational in the mid-1990's or can be blended with other high-purity plutonium to meet DOE requirements for weapon grade plutonium.

In FY 1989 our request for PFM is $72.2 million, which will allow for awarding of the long-lead procurements required for a project of the size of PFM.

New Production Reactor (NPR)

Significant New Production Reactor activities were deferred several years ago. Constrained budgets in the foreseeable future and uncertainties associated with weapons material requirements were a factor in the decision to defer NPR activities. While this budget request does not include funds for an NPR, the Department is actively evaluating and analyzing options for future production facilities. The recent analysis of the WNP-1 reactor, located near Richland, Washington, as a possible production facility is one example of this effort. WNP-1 is a partially completed reactor within the Washington Public Power Supply System. Additionally, the ongoing restoration and productivity retention programs will assure the continued reliability of the Savannah River Plant reactors.

We are committed to assuring the continued availability of nuclear materials in the near- and long-term and to restoring, revitalizing, and maintaining Department facilities to meet material requirements.

Environmental, Safety, and Health

(Chart 18) I would like to talk about what the Nuclear Materials Production program is doing to support the Department's commitment to environment, safety and health (ES&H). The Department's continuing policy is to conduct its operations in an environmentally safe and sound manner. DOE is committed to taking actions necessary to comply with applicable environmental statutes, regulations, and standards, while providing nuclear materials required for national defense. The FY 1988 budget request of $344.4 million for environmental, safety, and health activities demonstrates this emphasis and commitment.

Compliance actions are underway to meet the requirements of the Resource Conservation and Recovery Act, the Clean Air Act, the Clean Water Act, and the Comprehensive Environmental Response, Compensation and Liability Act. In addition, the Department is currently responding to Congress' request for a study of the cost and safety effects of containing the existing production reactors versus building a new contained reactor. We expect to submit this report by the March 15, 1987, due date.

To assure efficient usage of limited resources to comply with the evolving multitude of Federal, State, and local environmental requirements, the Office of Nuclear Materials is in the process of preparing long-range plans to address ES&H concerns. The ES&H long-range plans will be updated on an annual basis to reflect changing requirements/operations and funding availability.

At the Feed Materials Production Center (FMPC), Fernald, Ohio, FY 1988 construction project efforts will: provide significant improvements in controlling water contamination; modifying and upgrading facility ventilation systems to reduce the risk of airborne contamination; and providing for the improved control of on-site activities that have potential for inadvertent contamination of personnel and the environment. DOE is aggressively pursuing assessment and planning efforts to determine needed corrective actions, a schedule for implementation, and the associated funding required. Renovation activities for FMPC were initiated in FY 1982. The majority of the activities began in FY 1985 and continue through the 1980's. DOE is preparing an environmental impact statement on renovation activities to obtain public input to assist DOE in its decision making process. It is DOE's goal to comply with applicable ES&H requirements for FMPC operations and to reduce operational risk and environmental releases to as low as reasonably achievable levels.

The production complex must operate in an environmentally acceptable manner while providing the nuclear materials required for national defense. The FY 1988 budget request for ES&H activities provides for the beginning of new long-term solutions for priority problem areas.

SAFEGUARDS AND SECURITY

(Chart 19) In FY 1988, we are requesting $150.4 million in safeguards and security funding to address essential needs. Our request includes only one new project for Nuclear Materials Production, a security project at the Savannah River Plant which will provide the reactor areas with a consolidated security system. It will provide an automated access control system and consolidate all alarm monitoring and assessment functions. Modification of these systems will provide the capability to respond to increased detection, assessment, and access control needs. The new system will also improve the restriction of access to vital areas to authorized personnel.

NAVAL REACTORS SUPPORT

(Chart 20) The Nuclear Materials Production program budgets for the separative work to produce highly enriched uranium from the Department's gaseous diffusion complex for the Naval Reactors program. In FY 1988, the Naval Reactors program requires *Deleted* This highly enriched uranium will be used for fabrication of naval propulsion reactor cores and to continue naval fuel production in the new facility at the Savannah River Plant. The total Naval Reactor support request is $178.5 million. The $227.0 million requested for enriched uranium for the Naval Reactors program in FY 1989 will support a level of *Deleted* 1.5 metric ton increase above the FY 1988 request.

SUMMARY

(Chart 21) In summary, there are a number of challenges currently facing the Nuclear Materials Production Complex, i.e.:

- Maintaining production in aging facilities including those undergoing renovation;
- Maintaining production with concurrent increased ES&H and safeguards and security requirements and constraints;
- Maintaining required production levels within constrained budgets while accommodating increased ES&H and safeguards and security funding needs; and
- Developing sufficient budget and support to begin and sustain new initiatives required to assure a viable production complex into the next century.

We are taking aggressive actions to meet these challenges and look forward to the continued close communication with and support of the Congress which is essential to the success of these actions.

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT PROGRAM

INTRODUCTION

Goals

(Chart 22) The Defense Waste and Transportation Management (DWTM) program's principal goal is to provide essential support for nuclear materials production requirements by responsible management of radioactive and nonradioactive hazardous wastes.

DWTM must also maintain the capability and capacity to manage defense waste in a routine, safe, and cost-effective manner. The program emphasizes techniques for managing hazardous chemical wastes and mixed wastes to meet new and evolving environmental standards, and ensuring the availability of safe, secure, and efficient means of transporting radioactive and hazardous materials.

In June 1983, the President submitted to you the Defense Waste Management Plan which provided a baseline for permanent disposal of high-level waste and transuranic waste. Our FY 1988/FY 1989 programs continue implementation of that Plan.

The key provisions of the Plan included: (1) construction and operation of the Defense Waste Processing Facility (DWPF) at the Savannah River Plant; (2) construction of the Waste Isolation Pilot Plant (WIPP) located near Carlsbad, New Mexico, and performance of research and development for demonstration of geologic disposal of transuranic waste; (3) the construction and operation of the Hanford Waste Vitrification Plant (HWVP) to process high-level waste at Hanford for disposal in a Federal geologic repository; and (4) construction and operation of transuranic waste processing facilities at Richland, the Savannah River Plant, Oak Ridge, and Idaho sites, so that transuranic waste from those sites may be shipped to WIPP.

Implementation of the Defense Waste Management Plan requires additional operating funds in FY 1988. The completion of construction at the WIPP and DWPF facilities and the overlap of construction and operation funding requirements at DWPF and other facilities occurs primarily in FY 1988, thus resulting in increased fiscal needs at this time. I will talk about our specific site plans in just a moment.

The decision in 1983 to move from interim waste management to terminal disposal was a sound and prudent decision. Implementation of this plan, however, led to minimizing expenditures for interim waste management facilities. Timely startup of new processing and disposal facilities which will support terminal disposal, such as the DWPF, is clearly necessary to support continued production of nuclear materials.

RADIOACTIVE WASTE INVENTORIES

Radioactive Waste Types

(Chart 23) Radioactive wastes are primarily of three types--high-level, transuranic, and low-level--and are generated by DOE defense activities, the Naval nuclear propulsion program, and other DOE research and development work.

High-Level Waste

High-level waste is, in general, highly radioactive liquid waste resulting from plutonium production and enriched uranium recovery operations at the Savannah River Plant, Idaho, and Richland. Our objective is to achieve permanent disposal of high-level waste by immobilization, shipment to, and permanent disposal in a commercial geologic repository. Due to successful evaporation and concentration efforts at Hanford and the Savannah River Plant, the actual volume of stored high-level waste has been decreased by about 3 million gallons. Such efforts help to minimize the need for new interim waste storage tanks pending operation of immobilization facilities.

Transuranic Waste

Transuranic waste contains the long-lived, radioactive elements beyond uranium in the periodic table. The principal element in such waste is plutonium. The DOE orders allow other radionuclides to be managed as transuranic waste if the potential long-term hazards indicates that such management is warranted. The objective of the plan with regard to transuranic waste is to end interim storage and demonstrate permanent disposal in the WIPP.

Low-Level Waste

Low-level waste is radioactive waste not classified as high-level waste, transuranic waste, or spent nuclear fuel. Low-level waste is normally buried at the sites where it is generated. The Department generated and disposed of about 121,000 cubic meters of this waste during the past year.

Waste Inventories

(Chart 24) Defense Waste and Transportation Management manages the disposed and stored defense nuclear waste. The next chart shows the volume of waste that has been generated from almost 40 years of nuclear materials production activities.

We are generating increasing quantities of high-level waste in the Nuclear Materials Production program. In addition, production activities added about 6,000 cubic meters of transuranic waste during the past year.

FY 1988/FY 1989 BUDGET REQUEST

(Chart 25) I would now like to address FY 1988/FY 1989 funding needs. Our request for FY 1988 is $811.2 million, a 21 percent increase over FY 1987. The FY 1989 request is for $771.0 million.

(Chart 26) A summary of the reasons for our budget changes is shown in the following chart.

(Chart 27) The next chart depicts the impact that these major program components have on the total budget. Our operating expenses are increasing because we are adding a new dimension to our program--startup of DWPF to process high-level waste for disposal and startup of WIPP to demonstrate disposal of transuranic waste. We will continue to effectively manage wastes at all Defense Programs sites, and continue to progress in the development, construction, and operation of facilities outlined in the Defense Waste Management Plan, such as the HWVP. We are also increasing Resource

Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Conservation, and Liability Act (CERCLA) hazardous and mixed waste compliance demonstration actions.

Our funding needs will decrease in FY 1989 due to the transition of the WIPP and DWPF from construction to operations and the completion of several construction projects.

(Chart 28) I have included this next chart to show funding for the major program activities within DWTM. I will now describe each of these activities in more detail.

WASTE OPERATIONS AND PROJECTS

The principal objectives of this program are the safe and environmentally sound management of existing and newly generated waste from nuclear materials, and weapons production and naval propulsion operations, and implementation of processing and disposal activities for high-level and transuranic waste. The program includes the operation and maintenance of high-level waste storage tanks, bins, and related processing and storage facilities at Richland, the Savannah River Plant, and Idaho; the operation and maintenance of low-level waste burial grounds at the Savannah River Plant, Oak Ridge, Idaho, Richland, Los Alamos National Laboratory, Sandia National Laboratory, and the Nevada Test Site; the retrievable storage of transuranic waste at various sites; and the operation of low-level waste management facilities. In addition, the program is responsible for the construction and operation of facilities to prepare transuranic waste and high-level waste for disposal.

At INEL in FY 1988, high-level waste management activities, primarily in support of the Naval nuclear propulsion program, will continue. Planned maintenance of the New Waste Calcining Facility (NWCF) will be completed and the NWCF, which is operated on a campaign basis, will be restarted to solidify the backlog of liquid waste stored in tanks.

Construction of the Processing Experimental Pilot Plant, which will process transuranic waste prior to certification for emplacement in the WIPP, will continue. In its third full year of operation, the Stored Waste Examination Pilot Plant, INEL's transuranic waste examination and certification facility will handle 5,000 drums of waste to assure the availability of waste for WIPP when it opens in FY 1989.

Defense Waste Processing Facility

(Chart 29) Our request for FY 1988 for the DWPF operations and construction is $210.4 million. The DWPF will immobilize defense high-level waste at

Savannah River for storage, transportation to, and disposal in a geologic repository. The radioactive fraction of the high-level waste will be immobilized directly in borosilicate glass. The decontaminated salt fraction of the waste will be solidified as saltstone and disposed of at the Savannah River Plant as a low-level waste. When the DWPF is operational in FY 1990, we will work off the backlog of high-level waste from production operations at the Savannah River Plant, reaching a steady-state operation in about 15 years.

In FY 1988, preoperational activities will continue at an increased pace in anticipation of FY 1990 vitrification facility operation. These preoperational activities include equipment and process development and testing; training and preparation of technical manuals; and operability testing of equipment. Also in FY 1988, construction of the DWPF saltstone facility will be completed and disposal operations will commence. During FY 1989, we will have the first full year of saltstone facility operation, and preoperational activities at the vitrification facility will continue leading to operation in FY 1990.

It is essential that the current schedule for DWPF be maintained. Double-shell tank space in which to store newly generated high-level waste is very limited, and we must continue to remove waste from the old tanks before problems develop. Delay in the DWPF project, including the start of saltstone operations, will adversely impact our ability to support nuclear materials production.

Waste Isolation Pilot Plant

(Chart 30) We are requesting $86.4 million for WIPP operations and construction in FY 1988. This is the final year of funding for WIPP. The WIPP, now under construction near Carlsbad, New Mexico, is a research and development facility to demonstrate the safe disposal of radioactive waste from national defense programs. The WIPP is authorized by Public Law 96-164 and is exempt from licensing by the Nuclear Regulatory Commission.

The primary objective of WIPP is to demonstrate the technical and operational methods for permanent isolation of transuranic radioactive waste and to provide a facility for experiments on high-level waste in bedded salt. The facility is designed to receive, inspect, emplace, and store defense waste. It will have the capability of disposing of defense transuranic waste and conducting experiments with defense generated high-level waste.

The construction of permanent surface and underground facilities started in July 1983. Much construction progress has been made. Transuranic waste is now being certified for compliance with the WIPP waste acceptance criteria and stored for eventual shipment to the WIPP beginning in October 1988.

After a 5 year demonstration period, a decision will be made to leave or retrieve the transuranic waste.

In FY 1988, major project activities include completion of ventilation (fourth) shaft construction, completion of the WIPP safety analysis report and the operational readiness review, and initiation of the first TRUPACT assembly. The TRUPACT will be used to transport transuranic waste to WIPP for emplacement. As with DWPF, preoperational activities at WIPP will be increasing in level of activity. The activities are necessary to assure a smooth ramp-up toward full operation of the facility in FY 1989 and include environmental baseline monitoring, facility maintenance of operational subsystems, training, operational planning, and support for the State of New Mexico's Environmental Evaluation Group to assure that the concerns of the people of that State are addressed. During FY 1989, we will begin the emplacement of transuranic waste in WIPP.

(Chart 31) Included on the critical path for hot operations of WIPP in October 1988, is legislation to permanently withdraw WIPP land from public use. The legislation, drafted by the Department of Interior, is expected to be completed and submitted to Congress early in 1987.

Hanford Waste Vitrification Plant (HWVP)

(Chart 32) The proposed HWVP will incorporate high-level waste in borosilicate glass for permanent disposal in a Federal geologic repository. It serves the same function and is based on the same process technology as the DWPF now under construction at the Savannah River Plant except that an existing facility (B-Plant) will be used to decontaminate salt and process it for disposal onsite. While some refinements and testing are needed, the basic technology for vitrification of Richland high-level waste is in hand, and facility design and construction can be undertaken with confidence.

The broad scope of the Hanford defense waste EIS includes the NEPA documentation for the HWVP. The record of decision, based on the EIS, is expected to provide the basis for vitrification of high-level waste, onsite disposal of decontaminated salt immobilized in concrete, and disposal of previously separated and encapsulated cesium and strontium. The schedule is to publish the EIS and issue the record of decision early in FY 1988. The draft EIS was issued in May 1986. Nearly 2000 comments were received by September 1986, in the public participation process. Responses to the comments will be considered in a final version of the EIS by July 1987. Federal agencies and States will be briefed on the EIS in April 1987.

The architect-engineer for the HWVP has been selected, and conceptual design will be completed in FY 1987. Line item project activities will begin with the start of definitive design in FY 1988. Other activities in FY 1988 include: technology development and demonstration for feed preparation, glass formulation, and equipment and systems testing; technology transfer from the DWPF project; and participation in the National program to qualify vitrification waste forms for disposal in a Federal repository.

The current plan is to begin construction in FY 1990 and commence hot startup in FY 1998. The current total estimated cost for the HWVP is $680.0 million.

Waste Research and Development

(Chart 33) The Waste Research and Development program addresses the long-term management of defense radioactive wastes. The program consists of developing technologies for each waste type and assessing the associated hazards, costs, and environmental impacts of selection and implementation of long-term disposition alternatives. We are requesting $54.4 million for this important effort in FY 1988.

High-Level Waste Technology

We are developing technology that supports the long-term management of defense high-level waste at DOE sites. Our first emphasis was support to the DWPF at the Savannah River Plant, with the emphasis shifting to the proposed HWVP at Richland. The focus in FY 1988 is on waste form qualification for acceptance at a Federal geologic repository, including large-scale leaching tests and in-situ tests of simulated high-level waste in the WIPP. At the INEL, the feasibility of volume reduction process concepts for the calcined Idaho high-level waste will be evaluated. During FY 1989 technical support to the DWPF will increase.

Transuranic Waste Technology

The basic purposes of the Transuranic Waste Technology program are to support the demonstration of disposal of transuranic waste in the WIPP. During FY 1988, the program will: support activities needed to prepare remote-handled transuranic waste for shipment to WIPP starting in FY 1989; continue certification of contact-handled transuranic waste; complete establishment of a transuranic waste transportation system; continue buried waste immobilization studies at arid and humid sites; continue research and development activities for reducing the generation of transuranic waste in the future; initiate development of equipment for in-situ assay of buried waste and contaminated soil; and develop plans for safety evaluations of buried waste and contaminated soil.

Low-Level Waste Technology

The Low-Level Waste Technology program supports DOE waste operations for the disposal of low-level solid wastes. This program will assist disposal operations in meeting the DOE orders by increasing assurance and developing guidance for a systematic low-level waste management program. The objectives of this generic applied technology program are to: improve techniques for disposal by shallow-land burial; provide supporting documentation in assuring compliance with DOE criteria for disposal by shallow-land burial; develop cost-effective treatment processes to stabilize certain low-level waste streams; reduce volumes by generation avoidance; and evaluate disposal concepts such as greater confinement for application at DOE sites.

FY 1988 activities will include examining the role of waste forms in minimizing leaching of radionuclides from low-level waste; comparing disposal site performance with DOE requirements; documenting technical solutions to perceived problem areas; and evaluating central or regional treatment facilities.

WIPP Research and Development

The mission of WIPP is to provide a research and development facility to demonstrate the safe disposal of defense transuranic waste. To implement this, the research and development program includes: site characterizations and evaluations; impacts of heat from radioactive wastes on the salt formulation; plugging and sealing waste storage areas; performance of waste packages emplaced in salt; and evaluation of compliance with 40 CFR 191. The FY 1988 program will consist of completion of the hydrological model documentation, completion of the geohydrological report on the WIPP site; preliminary evaluation of seal design; continuation of waste package integrity studies; and continuation of performance assessment methodology development for compliance with 40 CFR 191. During FY 1989, funding to continue the FY 1988 activities will increase slightly.

Hazardous Waste Research and Development

In FY 1988, the Hazardous Waste Research and Development program will evaluate the potential of developing field demonstration programs based on research and development efforts in the areas of treatment of nitrate wastes, cleanup and reclamation of waste acids, and reduction in waste generation.

Hazardous Waste and Remedial Actions

(Chart 34) The Hazardous Waste and Remedial Actions program is requesting $29.6 million in FY 1988. This program provides support to Defense Programs on hazardous and mixed wastes and decontamination and decommissioning activities. The mission of the Hazardous Waste and Remedial Actions program is two-fold: (1) to assist the Defense Programs complex in meeting its obligations under the RCRA and the CERCLA; and (2) to either return to useful service, or otherwise safely manage or dispose of contaminated defense surplus facilities under the defense Decontamination and Decommissioning program.

Hazardous Waste Activities

In FY 1988, the hazardous waste activities are needed to meet the terms of compliance agreements and consent orders which Defense Programs sites have entered into with State and Federal regulatory agencies.

Technology support will focus on implementing a coordinated Defense Programs approach to management of hazardous and mixed wastes based on the recommendations of the Strategic Alternatives Study. The Strategic Alternatives Study is being conducted by the Office of Defense Waste and Transportation Management to examine options for management of Defense Programs hazardous and mixed wastes and to recommend a preferred approach for management of these wastes.

Information systems activities will continue to support hazardous and mixed waste technology and demonstration efforts through operation and maintenance of the DOE Waste Information Network.

Demonstration actions include permitting and initiation of construction of a low-level mixed waste disposal facility at the Nevada Test Site; initiation of projects at Hanford and Idaho to demonstrate treatment, storage, and disposal of hazardous and mixed waste in compliance with RCRA; initiation of highest priority CERCLA remedial action demonstrations at Defense Programs sites; and continuation of the cooperative Superfund Innovative Technology Evaluation demonstration program with the Environmental Protection Agency and the Department of Defense.

Decontamination and Decommissioning

(Chart 35) The Defense Programs Decontamination and Decommissioning program provides for the management of 226 radioactively contaminated surplus facilities formerly used in support of Defense Programs. In FY 1988, the program will continue providing necessary surveillance and maintenance to assure these facilities remain in a safe condition. The program will also provide for continuation of 14 ongoing decommissioning projects for surplus facilities located at Mound, Idaho, Grand Junction, Oak Ridge, and Richland. Two projects will be completed (Strontium Semiworks at Richland and the R-149 Laboratory at Mound) and high priority remedial work will be initiated at the Grand Junction site for removal of uranium contamination resulting from past processing of uranium ore. These projects will reduce potential hazards and the need for surveillance and maintenance and, in some cases, make the facilities available for reuse.

Transportation Management

(Chart 36) The Transportation Management program request of $8.9 million is needed to ensure the continued safe, secure, and efficient movement of radioactive, hazardous, and other materials and property to meet Department-wide needs. This includes the development and engineering of packaging certifiable by DOE and/or the Nuclear Regulatory Commission; the investigation of concepts and technologies for future packaging and transportation systems; the maintenance and advancement of capabilities to carry out such investigations; and the establishment, implementation, and enforcement of operational policies and procedures relating to the transportation of the Department's property and materials. A corollary mission includes support for the Office of Civilian Radioactive Waste Management (RW) in related areas covered by the Nuclear Waste Policy Act. The program provides transportation and traffic management support to all DOE nonclassified programs. It assures that shipment of materials, and especially radioactive materials, is made in full compliance with Federal, State, local, and international transportation regulations.

Work includes a base technology program which has DOE-wide applicability for all DOE nuclear program transportation needs. This base technology is essential to establish and support DOE technical positions regarding regulatory provisions of packaging design, analysis, test, and operation. The base technology program includes packaging design, development, materials investigations, standards development, testing, test facilities development, operational safety and risk analyses, EIS preparation, logistics and economic analyses, regulatory issue analyses, and data base development. These activities are conducted at the Sandia National Laboratory. Because of the close relationship of the base technology program and regulatory and technical requirements, coordination with RW regarding its packaging development program is a critical element of this work.

Repository Fee

(Chart 37) In April 1985, the President supported DOE's recommendation to use the repositories to be constructed under the Nuclear Waste Policy Act of 1982, Public Law 97-425, for disposal of defense high-level waste.

Therefore, the Department is proceeding with arrangements to dispose of defense waste in the same repositories used for civilian waste. On December 2, 1986, a Federal Register Notice of Inquiry was published that solicited public comment on proposed alternative methods of calculating the appropriate fee to be paid by DOE into the Nuclear Waste Fund. The Department intends to refine the approach to calculating the fee after reviewing the public comments and use that approach to support requests for appropriations. No funding for the repository fee is included in the FY 1988 request.

Summary

(Chart 38) In summary, the DWTM budget does increase significantly. However, the Waste Operations program funding remains level, and there is a slight increase requested for the Hazardous Waste and Remedial Actions program. The major increases in program reflect the transition from interim operations to terminal disposal with the approaching completion of the WIPP and DWPF programs, and the initiation of design of the HWVP at Richland. Finally, we are not requesting funding in FY 1988 for the repository fee.

This completes my presentation. I shall be happy to answer any questions you may have on either the Nuclear Materials Production program or the Defense Waste and Transportation Management program.

CHART 1

FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST (IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
NUCLEAR MATERIALS PRODUCTION	$1,767.5	$1,858.4	$1,881.6	$2,220.0
DEFENSE WASTE AND TRANSPORTATION MANAGEMENT	618.0	672.2	811.2	771.0
TOTAL	$2,385.5	$2,530.6	$2,692.8	$2,991.0

CHART 2

NUCLEAR MATERIALS PRODUCTION FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST

PROGRAM GOALS

- MAINTAIN BASIC PRODUCTION CAPABILITY AND CAPACITY
- MEET NUCLEAR WEAPONS STOCKPILE MEMORANDUM (NWSM) AND OTHER NEAR-TERM OPERATIONAL REQUIREMENTS
- CONTINUE TO OPERATE NUCLEAR MATERIALS PRODUCTION FACILITIES IN A SAFE, SECURE AND ENVIRONMENTALLY ACCEPTABLE MANNER

CHART 3 DELETED

CHART 4 DELETED

CHART 5 DELETED

CHART 6 DELETED

CHART 7

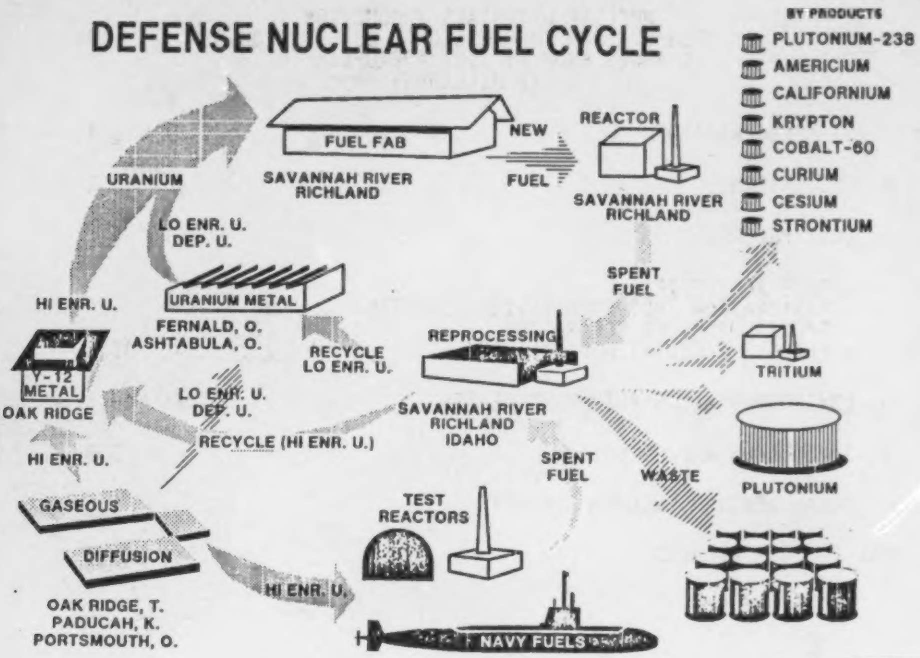

DEFENSE NUCLEAR FUEL CYCLE
BY PRODUCTS
PLUTONIUM-238
AMERICIUM
CALIFORNIUM
KRYPTON
COBALT-60
CURIUM
CESIUM
STRONTIUM
FUEL FAB
SAVANNAH RIVER
RICHLAND
NEW
FUEL
REACTOR
SAVANNAH RIVER
RICHLAND
URANIUM
LO ENR. U.
DEP. U.
SPENT
FUEL
HI ENR. U.
URANIUM METAL
FERNALD, O.
ASHTABULA, O.
RECYCLE
LO ENR. U.
REPROCESSING
TRITIUM
Y-12
METAL
OAK RIDGE
LO ENR. U.
DEP. U.
SAVANNAH RIVER
RICHLAND
IDAHO
RECYCLE (HI ENR. U.)
HI ENR. U.
SPENT
FUEL
WASTE
PLUTONIUM
GASEOUS
DIFFUSION
TEST
REACTORS
OAK RIDGE, T.
PADUCAH, K.
PORTSMOUTH, O.
HI ENR. U.
NAVY FUELS

CHART 8

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES				
REACTOR OPERATIONS	$ 541.7	$ 576.5	$ 580.7	$ 630.3
PROCESSING OF NUCLEAR MATERIALS	464.8	453.1	455.7	485.2
SUPPORTING SERVICES	248.1	226.5	235.6	246.7
URANIUM ENRICHING	169.6	176.7	193.0	242.3
PROGRAM DIRECTION	22.3	22.5	24.0	25.0
TOTAL OPERATING	1,446.5	1,455.3	1,489.0	1,629.5
CAPITAL EQUIPMENT	109.5	112.3	101.4	105.4
CONSTRUCTION	211.5	290.8	291.2	485.1
TOTAL	$1,767.5	$1,858.4	$1,881.6	$2,220.0

CHART 9

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
CHANGES FROM FY 1987 APPROPRIATION
(IN MILLIONS)

FY 1987 APPROPRIATION		$1,858.4
o ESCALATION		+ 63.8
o CORE PROGRAM		
- BASE ACTIVITIES	- 82.1	
- RESTORATION AND PRODUCTIVITY RETENTION	+ 33.2	
- SPECIAL ISOTOPE SEPARATION	- 20.7	
- PROCESS FACILITY MODIFICATION	- 23.7	- 93.3
o ENVIRONMENTAL, SAFETY, AND HEALTH		+ 46.6
o SAFEGUARDS AND SECURITY		- 3.5
o NAVAL REACTOR PROGRAM SUPPORT		+ 9.6
TOTAL FY 1988 REQUEST		$1,881.6

CHART 10

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
MAJOR ACTIVITIES
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
CORE PROGRAM				
BASE ACTIVITIES	$1,063.5	$1,057.6	$1,014.6	$1,088.6
RESTORATION AND PRODUCTIVITY RETENTION	80.5	87.2	120.7	209.8
SPECIAL ISOTOPE SEPARATION	78.6	74.7	56.0	101.0
PROCESS FACILITY MODIFICATION	20.9	40.2	17.0	72.2
TOTAL CORE PROGRAM	1,243.5	1,259.7	1,208.3	1,471.6
ENVIRONMENTAL, SAFETY, AND HEALTH	234.3	287.5	344.4	362.5
SAFEGUARDS AND SECURITY	129.8	148.8	150.4	158.9
NAVAL REACTOR SUPPORT	159.9	162.4	178.5	227.0
TOTAL NUCLEAR MATERIALS PRODUCTION	$1,767.5	$1,858.4	$1,881.6	$2,220.0

CHART 11

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
BASE ACTIVITIES

o MAINTAIN BASIC PRODUCTION CAPACITY AND CAPABILITY THROUGH OPERATION OF:

- FEED PRODUCTION PLANTS AT FERNALD, ASHTABULA, AND OAK RIDGE
- N REACTOR AT RICHLAND AND THREE SAVANNAH RIVER REACTORS
- PUREX PROCESSING PLANT AT RICHLAND, TWO PROCESSING CANYONS AT SAVANNAH RIVER, AND PROCESSING PLANT AT IDAHO
- SCRAP RECOVERY FACILITIES AT ALBUQUERQUE, OAK RIDGE, RICHLAND, SAN FRANCISCO, AND SAVANNAH RIVER
- SUPPORT FACILITIES AT IDAHO, OAK RIDGE, RICHLAND, AND SAVANNAH RIVER
- TECHNOLOGY DEVELOPMENT ACTIVITIES AT VARIOUS LOCATIONS

CHART 12

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST

SAVANNAH RIVER REACTORS

o C REACTOR PLACED IN COLD STANDBY STATUS IN FY 1987

O REACTOR SIMULATOR NOW IN FULL OPERATIONS FOR REACTOR TRAINING

o NO KNOWN LIFE LIMITING MECHANISMS HAVE BEEN IDENTIFIED FOR P, K, AND L REACTORS

O SAVANNAH RIVER REDUCED REACTOR POWER APPROXIMATELY 25% IN NOVEMBER 1986 AFTER IDENTIFYING UNCERTAINTIES IN EMERGENCY COOLING SYSTEM (ECS) PERFORMANCE EVALUATIONS

O IN COURSE OF NATIONAL ACADEMY OF SCIENCES PANEL REVIEW OF DOE REACTORS, PANEL NOTIFIED DOE ON MARCH 9, 1987 THAT THEY COULD NOT CONCLUDE WITH CONFINDENCE THAT ECS CAN WITHSTAND A SEVERE "LOSS-OF-COOLANT" ACCIDENT

O DOE DECIDED TO LIMIT REACTORS TO APPROXIMATELY 50% POWER PENDING SUPPORTING DATA FOR INCREASED POWER

O INTERIM PANEL REPORT ON PRODUCTION REACTORS EXPECTED MAY 1987

CHART 13

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST

N REACTOR

- CHERNOBYL INCIDENT FOCUSED TREMENDOUS ATTENTION ON N REACTOR
- REVIEWS BY DOE AND INDEPENDENT CONSULTANTS CONFIRMED THAT A CHERNOBYL-TYPE ACCIDENT IS NOT POSSIBLE AT N REACTOR
- N REACTOR WAS PLACED IN A STAND DOWN CONDITION ON JANUARY 7, 1987, FOR A PERIOD OF APPROXIMATELY 6 MONTHS TO ALLOW FOR THE ACCELERATION OF PORTIONS OF THE SAFETY ENHANCEMENT PROGRAM
- DOE TERMINATED ACTIVITIES TO EXTEND THE LIFE OF N REACTOR BEYOND THE MID-1990'S

CHART 14

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST

PLUTONIUM PROCESSING OPERATIONS AT HANFORD

- PROCESSING OPERATIONS SUSPENDED BY FIELD OFFICE MANAGER OCTOBER 8, 1986, DUE TO CRITICALITY PREVENTION SPECIFICATION VIOLATIONS
- REVIEWS INDICATED IMPROVEMENTS REQUIRED IN CRITICALITY CONTROL SYSTEMS, TRAINING, WORK AUTHORIZATION/CONFIGURATION CONTROL PROCESS, INTERNAL COMMUNICATIONS, MANAGEMENT SYSTEMS AND QUALITY ASSURANCE
- SHUTDOWN WILL NOT IMPACT WEAPONS PRODUCTION
- FACILITY RESTART ANTICIPATED:
  - PUREX - FEBRUARY 1987
  - PLUTONIUM RECLAMATION FACILITY (PRF) - APRIL 1987
  - METAL PRODUCTION LINE (RMC) - JULY 1987
- PROCESSING FACILITIES (PRIMARILY PRF AND RMC) DO NOT MEET ALL CURRENT REQUIREMENTS INCLUDING SEISMIC: HOWEVER, ACCIDENT CONSEQUENCES ARE WELL WITHIN 10 CFR 100 REQUIREMENTS

CHART 15

RESTORATION AND RETENTION
(IN MILLIONS)

	TEC	FY 1986	FY 1987	FY 1988	FY 1989
FACILITY RESTORATION (82-D-124)	$ 367.3	$ 42.5	$ 6.1	$ 15.4	$ 8.2
FUEL PROCESSING RESTORATION (85-D-139)	284.0	18.4	36.6	36.4	73.7
PRODUCTIVITY RETENTION (86-D-149)	356.0	19.6	44.5	68.9	127.9
TOTAL		$ 80.5	$ 87.2	$ 120.7	$ 209.8

FACILITY RESTORATION
- o COMPLETES UPGRADE OF FACILITIES TO MAINTAIN THE PRODUCTION OF NUCLEAR MATERIALS IN SUPPORT OF NATIONAL DEFENSE PROGRAMS.

FUEL PROCESSING RESTORATION
- o REPLACES DETERIORATED URANIUM RECOVERY PROCESS AT IDAHO FUELS PROCESSING FACILITY.
- o PROVIDES NEW LOW-LEVEL LIQUID WASTE TREATMENT AND DISPOSAL SYSTEM.

PRODUCTIVITY RETENTION
- o PROVIDES FOR MODERNIZATION AND UPGRADE OF EXISTING PRODUCTION FACILITIES TO INCREASE OPERATING AVAILABILITY AND/OR EFFICIENCY OF CRITICAL PRODUCTION COMPONENTS.

CHART 16

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
SPECIAL ISOTOPE SEPARATION
(IN MILLIONS)

	FY 1986	FY 1987	FY 1988	FY 1989
OPERATING EXPENSES	$ 70.3	$ 49.1	$ 50.0	$ 50.0
CAPITAL EQUIPMENT	4.5	1.0	1.0	1.0
CONSTRUCTION (TEC $530M)	3.8	24.6	5.0	50.0
TOTAL	$ 78.6	$ 74.7	$ 56.0	$ 101.0

- o COMPLETE COMPONENT PRELIMINARY DESIGNS FOR LASER AND SEPARATOR SYSTEM
- o CONTINUE OPERATION OF THE ENGINEERING DEMONSTRATION SYSTEM (EDS)
- o CONTINUE FACILITY DEFINITIVE DESIGN
- o COMPLETE ENVIRONMENTAL IMPACT STATEMENT
- o FACILITY CONSTRUCTION WILL NOT BEGIN UNTIL COMPLETION OF KEY DEVELOPMENT ACTIVITIES

CHART 17

PROCESS FACILITY MODIFICATIONS (IN MILLIONS)

	TEC	FY 1986	FY 1987	FY 1988	FY 1989
PROCESS FACILITY MODIFICATIONS, RL (84-D-135)	$255.0	$20.9	$40.2	$17.0	$72.2

OBJECTIVE

o PROVIDE A CAPABILITY AT PUREX PLANT WHICH CURRENTLY DOES NOT EXIST FOR PROCESSING AND RECOVERING PLUTONIUM FROM FFTF FUEL

SCOPE

o MULTI-LEVEL STRUCTURE ADJACENT TO PUREX WILL INCLUDE:
  - CASK RECEIPT AND DECONTAMINATION
  - WATER POOL FOR FUEL UNLOADING AND STORAGE
  - SHIELDING CELL FOR FUEL DISASSEMBLY, ROTARY SHEARING, DISSOLUTION, WASTE HANDLING
  - PRODUCT BLENDING
  - PRODUCT LAG STORAGE
  - OFFGAS TREATMENT

SCHEDULE

o COMPLETE CONSTRUCTION - 9/94

CHART 18

ENVIRONMENTAL, SAFETY, AND HEALTH (IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$189.7	$ 219.2	$ 243.0	$ 253.2
EQUIPMENT	$21.3	25.7	20.6	21.3
CONSTRUCTION				
GENERAL PLANT PROJECTS	11.2	10.9	14.6	15.1
FY 1989 NEW STARTS	0	0	0	15.9
82-D-126 REACTOR SAFETY AND RELIABILITY, RL	1.8	0	0	0
83-D-148 NONRADIOACTIVE HAZARDOUS WASTE MGMT, SR	1.7	0	4.2	2.7
86-D-154 EFFLUENT TREATMENT FACILITY, SR	8.6	13.4	19.2	8.8
87-D-149 REDUCED CHEMICAL DISCHARGES, RL	0	3.1	0	0
87-D-150 RAD. LIQUID EFFLUENT TREATMENT FAC., RL	0	3.9	5.0	6.1
87-D-152 ENVIRONMENTAL PROTECTION PLANTWIDE, SR	0	1.5	2.8	2.2
87-D-159 ES&H IMPROVEMENTS, PHASES I AND II, FMPC, OH	0	9.8	35.0	37.2
SUBTOTAL CONSTRUCTION	$ 23.3	42.6	80.8	88.0
TOTAL PRODUCTION	$ 234.3	$ 287.5	$ 344.4	$ 362.5

CHART 19

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
(IN MILLIONS)

SECURITY FUNDING

	FY 1986 ACTUAL	FY 1986 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$ 102.8	$ 109.1	$ 111.9	$ 115.7
EQUIPMENT	8.0	14.0	8.2	8.5
CONSTRUCTION				
GENERAL PLANT PROJECTS	3.4	5.1	4.7	4.8
84-D-134 SAFEGUARDS AND SECURITY IMPROVEMENTS, SR	6.3	11.5	9.7	11.6
84-D-137 FACILITY SECURITY SYSTEM UPGRADE, ID	4.7	0.3	0	0
85-D-137 VAULT SYSTEM, RL	1.9	0	0	0
86-D-156 PLANTWIDE SAFEGUARDS SYSTEMS, SR	2.7	8.8	13.0	11.6
88-D-153 ADDITIONAL REACTOR SAFEGUARDS, SR	0	0	2.9	6.7
SUBTOTAL CONSTRUCTION	19.0	25.7	30.3	34.7
TOTAL SECURITY FUNDING	$ 129.8	$ 148.8	$ 150.4	$ 158.9

CHART 20

NUCLEAR MATERIALS PRODUCTION
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
(IN MILLIONS)

NAVAL REACTOR SUPPORT

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
NAVAL REACTORS PROGRAM SUPPORT	$ 159.9	$ 162.4	$ 178.5	$ 227.0

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CHART 21

CHALLENGES FACING NUCLEAR MATERIALS IN FY 1988 AND BEYOND

- o MAINTAINING REQUIRED PRODUCTION IN AGING FACILITIES
- o MINIMIZING IMPACT ON PRODUCTION OF EXTENSIVE RENOVATION/UPGRADE ACTIVITIES
- o ASSURING CONTINUED FACILITY OPERATION IN AN INCREASINGLY PUBLIC ENVIRONMENT
- o MAINTAINING REQUIRED OPERATIONS WHILE ACCOMMODATING INCREASED ES&H AND SAFEGUARDS AND SECURITY REQUIREMENTS
- o PROVIDING FOR NEW INITIATIVES REQUIRED TO ASSURE A VIABLE COMPLEX INTO THE NEXT CENTURY
- o PREPARING FOR TRANSITION TO PERMANENT DISPOSAL OF HIGH-LEVEL AND TRANSURANIC WASTE
- o ADDRESSING REGULATORY COMPLIANCE FOR HAZARDOUS AND MIXED WASTE

CHART 22

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST

PROGRAM GOALS

- o SUPPORT NUCLEAR MATERIAL PRODUCTION REQUIREMENTS
- o MAINTAIN BASIC CAPABILITY AND CAPACITY
- o CONTINUE IMPLEMENTATION OF DEFENSE WASTE MANAGEMENT PLAN

CHART 23

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
RADIOACTIVE WASTE TYPES

HIGH-LEVEL WASTE:	WASTE FROM REPROCESSING CHARACTERIZED BY HIGH HEAT AND LONG LASTING HAZARD
TRANSURANIC WASTE:	LOW-LEVEL WASTE CONTAMINATED WITH CERTAIN LONG-LIVED ALPHA ACTIVITY IN EXCESS OF 100 nCi/g.
LOW-LEVEL WASTE:	OTHER WASTE CONTAMINATED WITH SHORT-LIVED RADIOACTIVITY. INCLUDES CONTAMINATED EQUIPMENT, COMPONENTS, CLOTHING, TRASH, SLUDGES, ETC.

CHART 24

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT

Defense Waste Inventory

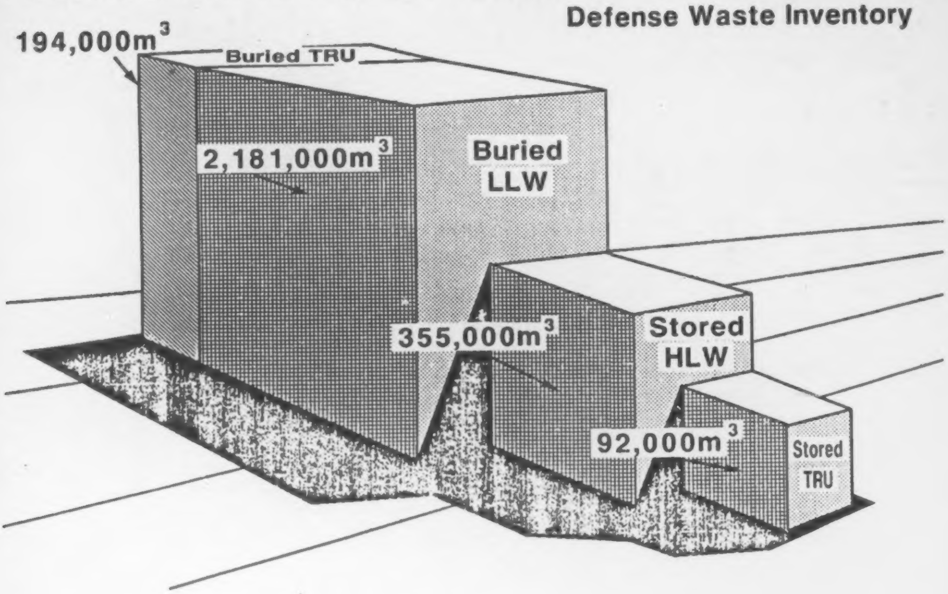

CHART 25

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES				
WASTE OPERATIONS AND PROJECTS	$ 275.0	$ 329.6	$ 401.6	$ 432.0
WASTE RESEARCH AND DEVELOPMENT	73.8	69.3	53.1	60.6
HAZARDOUS WASTE AND REMEDIAL ACTIONS	18.8	23.2	27.0	28.1
TRANSPORTATION MANAGEMENT	8.9	8.5	8.4	10.7
PROGRAM DIRECTION	2.1	2.1	2.5	2.6
TOTAL OPERATING EXPENSES	378.6	432.7	492.6	534.0
CAPITAL EQUIPMENT	42.0	36.2	44.4	46.2
CONSTRUCTION	197.4	203.3	274.2	190.8
TOTAL	$ 618.0	$ 672.2	$ 811.2	$ 771.0

CHART 26

CHANGES FROM FY 1987 APPROPRIATION (IN MILLIONS)

FY 1987 APPROPRIATION		$672.2
o ESCALATION		+ 19.3
o WASTE OPERATIONS AND PROJECTS		
- DEFENSE WASTE PROCESSING FACILITY	+ 21.0	
- WASTE ISOLATION PILOT PLANT	+ 62.8	
- HANFORD WASTE VITRIFICATION PLANT	+ 7.5	
- OTHER OPERATIONS	+ 3.2	
- OTHER PROJECTS	+ 39.8	+134.3
o WASTE RESEARCH AND DEVELOPMENT		- 19.3
o HAZARDOUS WASTE AND REMEDIAL ACTIONS		+ 4.8
o TRANSPORTATION MANAGEMENT		- 0.4
o PROGRAM DIRECTION		+ 0.3
TOTAL FY 1988 REQUEST		$811.2

CHART 27

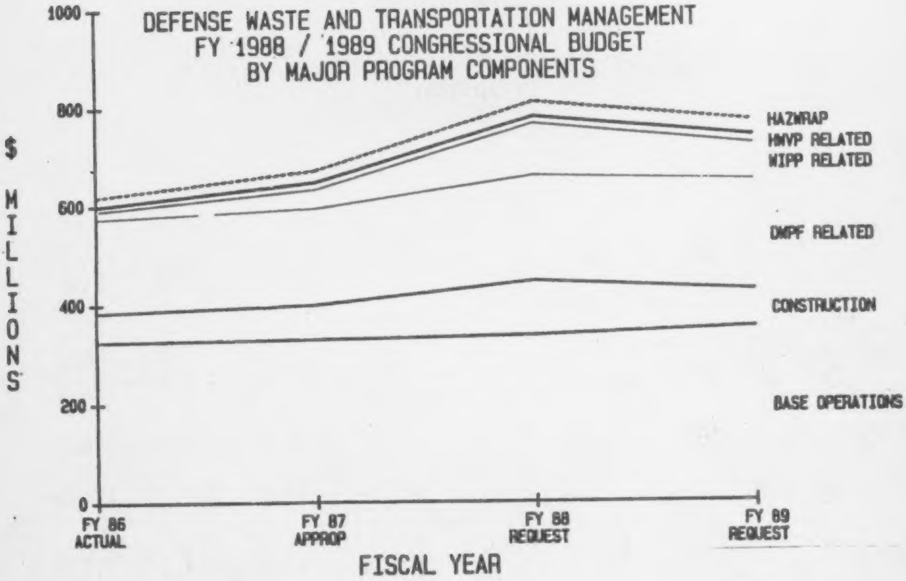

CHART 28

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
MAJOR ACTIVITIES
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
WASTE OPERATIONS AND PROJECTS				
DWPF	$ 174.5	$ 186.6	$ 210.4	$ 217.0
WIPP	4.3	22.7	86.4	51.7
HWVP	0	0	7.5	10.0
ALL OTHER	331.1	356.9	411.4	385.0
	$ 509.9	$ 566.2	$ 715.7	$ 663.7
WASTE RESEARCH AND DEVELOPMENT	76.9	71.0	54.5	62.5
HAZARDOUS WASTE AND REMEDIAL ACTIONS	19.3	23.9	29.6	31.0
TRANSPORTATION MANAGEMENT	9.8	9.0	8.9	11.2
PROGRAM DIRECTION	2.1	2.1	2.5	2.6
TOTAL	$ 618.0	$ 672.2	$ 811.2	$ 771.0

CHART 29

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
DEFENSE WASTE PROCESSING FACILITY
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$ 16.7	$ 50.2	$ 88.3	$ 106.9
CAPITAL EQUIPMENT	1.9	3.3	1.1	2.3
CONSTRUCTION (TEC $945M)	155.9	133.1	121.0	107.8
	$ 174.5	$ 186.6	$ 210.4	$ 217.0

- o RAMP-UP OF PREOPERATIONAL ACTIVITIES
- o BEGIN OPERATION OF SALTSTONE PLANT
- o PROVIDE OPERATIONAL AND LABORATORY SUPPORT
- o CONTINUE OPERABILITY TESTING TO CONFIRM DESIGN CRITERIA
- o COMPLETE LARGE-SCALE LEACHING TESTS OF GLASS WASTE

CHART 30

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
WASTE ISOLATION PILOT PLANT (WIPP)
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
OPERATING EXPENSES	$ 12.9	$ 22.7	$ 36.1	$ 43.0
CAPITAL EQUIPMENT	8.2	0.0	14.4	8.7
CONSTRUCTION (TEC $413.3M)	-16.8	0.0	35.9	0.0
	$ 4.3	$ 22.7	$ 86.4	$ 51.7

- o ISSUE FINAL WIPP SAFETY ANALYSIS REPORT
- o COMPLETE FACILITY OPERATIONAL READINESS REVIEW
- o COMPLETE VENTILATION SHAFT CONSTRUCTION
- o INITIATE ASSEMBLY OF TRUPACT FLEET

CHART 31

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
WIPP LEGISLATIVE LAND WITHDRAWAL

- o CRITICAL PATH FOR HOT OPERATIONS - OCTOBER 1988
- o DOI RESPONSIBILITY
  - STARTED DRAFTING JUNE 1982
  - DRAFT COMPLETE IN EARLY CY 1987
- o DRAFT LEGISLATION IN OMB

CHART 32

DEFENSE WASTE AND TRANSPORTATION MANAGEMENT
FY 1988/FY 1989 CONGRESSIONAL BUDGET REQUEST
HANFORD WASTE VITRIFICATION PLANT
(IN MILLIONS)

	FY 1986 ACTUAL	FY 1987 APPROP.	FY 1988 REQUEST	FY 1989 REQUEST
CONSTRUCTION (TEC $680M)	$ 0.0	$ 0.0	$ 7.5	$ 10.0

- o HWVP WILL PLACE HIGH-LEVEL WASTE IN GLASS FOR PERMANENT DISPOSAL AT RL
- o SAME PROCESS TECHNOLOGY AS DWPF
- o INITIATE DEFINITIVE DESIGN

STATEMENT OF MICHAEL B. SEATON

Mr. Chairman and members of the Committee, I am Michael B. Seaton, Deputy Assistant Secretary for Security Affairs. It is a pleasure to appear before you today to address the Department of Energy's Security Affairs programs of Nuclear Safeguards and Security (including the Office of Classification), Security Investigations, and Verification and Control Technology, and our Fiscal Year (FY) 1988/FY 1989 budget request required to carry out these programs.

This is my first opportunity to testify before this Committee. Until my retirement on October 1, 1985, I served 23 years as a career military officer with the U.S. Air Force. In April 1985 Secretary Herrington asked me to join a team of professionals to conduct a study of the effectiveness and efficiency of the safeguards and security program at the Department's nuclear weapons and special nuclear materials facilities. This team conducted a 5-month assessment of safeguards and security and presented recommendations to the Secretary on August 30, 1985. Subsequently, the Secretary asked me to implement the recommendations. Accordingly, I retired from the Air Force and was appointed Director, Office of Safeguards and Security. Then, on October 12, 1986, I was appointed Deputy Assistant Secretary for Security Affairs, with the additional responsibility for the Offices of Classification and International Security Affairs.

Mr. Chairman, I intend to keep you informed on the activities of interest to your Committee in the Security Affairs area. I will be pleased to meet with the members of this Committee or the Committee staff at anytime.

SECURITY AFFAIRS

Security Affairs' programs play an important role in the Department's national security mission. Security Affairs' programs are the Department's cornerstone in: preventing the theft or sabotage of nuclear weapons, materials, facilities, and classified information. My office develops and implements policy for managing the classification and declassification of information. We also provide nuclear weapons systems expertise to the Intelligence Community, control proposed exports of nuclear materials technology and equipment, and provide technology and equipment necessary to monitor treaty compliance of foreign nuclear weapons programs. My office also provides technical and analytical support for DOE's role in arms control negotiations, policy formulation, and implementation.

I want to say a word at this point about the corporate commitment to effective safeguards and security, both on the part of DOE officials and officials of major contractor organizations. The Nation is indeed fortunate to have the caliber of men and women in both the Federal and contract workforces. Their dedication is critical to the Department's safeguards and security mission. The outstanding support and commitment by our protective force, major nuclear facilities, and research and development contractors surprised me as I observed it firsthand over the past 18 months. Every member of Congress and the American people shall know that we and our contractors view our nuclear safeguards and security responsibilities as a grave public trust. Our commitment matches that trust.

FY 1988/FY 1989 BUDGET

Security Affairs requests $210.4 million for FY 1988, a net increase of 9 percent over FY 1987 with nearly all the increase for Nuclear Safeguards and Security. This consists of $77.8 million for Nuclear Safeguards and Security (including $4.5 million for Classification); $32.0 million for Security Investigations; and $100.6 million for Verification and Control Technology. Security Affairs requests $255.2 million for FY 1989, a net increase of 21 percent over FY 1988, with the majority of the increase for the Verification and Control Technology Program.

NUCLEAR SAFEGUARDS AND SECURITY

The Nuclear Safeguards and Security program has three major program goals:

- To prevent the theft, sabotage, or loss of nuclear weapons and their components. This also includes special nuclear materials, the facilities that produce it, and protection for classified information;

- To provide a safeguards and security technology base that virtually all Federal agencies have depended upon for several years; and
- To support nuclear nonproliferation and national security objectives concerning the protection of special nuclear materials overseas.

As I discussed earlier, my first detailed assignment with the Department of Energy (DOE) was as a member of a Special Project Team. This team was created by the Secretary of Energy to assess the adequacy, effectiveness, and management of DOE's safeguards and security program, and to recommend actions needed to ensure that the level of protection was both effective and efficient throughout the nuclear weapons complex.

Two years ago, the other members of the team and I held extensive onsite reviews at all DOE major facilities. We conducted hundreds of interviews with senior management, staff, and security force personnel throughout the complex. We also reviewed the management and program actions that had been taken, were underway, or proposed.

In the report to the Secretary, we concluded that, overall, the physical safeguards and security systems at DOE's nuclear weapons facilities were satisfactory, and improvements were continuing to be made. In addition, recent security enhancements throughout the complex had significantly reduced or eliminated many protection vulnerabilities previously identified. More importantly, the study concluded that, while every facility had not completed its physical security system improvements, any adversary who attempts to gain control over or steal a nuclear weapon, a critical weapon component, or special nuclear material would face a high probability of failure. I believe that finding still stands.

The review identified the need for a number of management improvements. An innovative implementation plan, called "Operation Cerberus," was developed and executed to carry out these improvements. Nine task force committees were organized to work on the projects identified by Operation Cerberus. Operation Cerberus was concluded on November 1, 1986, with follow-on developments being directed by the Office of Safeguards and Security (OSS). This increased emphasis has had an immediate and direct impact on Headquarters and facility protection and further improvements are anticipated as Cerberus initiatives continue to be institutionalized in the safeguards and security program.

RECENT INITIATIVES

Before discussing in detail the specific program areas for which funding is requested, I would like to briefly discuss the status of several other initiatives the Department has undertaken to enhance our overall security operations. The DOE security forces at our fixed sites are contractor operations. They are highly motivated, provided with state-of-the-art equipment, and trained in the latest tactics and procedures.

The Department has continued to focus direct management support on top quality training for its contractor protective force personnel at the Central Training Academy (CTA) in Albuquerque, NM. During the past year, the CTA has taught courses in hostage negotiations, supervisory qualification, firearms safety, tactical response, arrest authority, and use of force. In addition, the CTA's expertise is being applied to other safeguards and security areas of concern. For example, the CTA has examined standardization and safety aspects of firearms throughout DOE facilities. In addition, another assessment is underway at the CTA to evaluate and recommend options for DOE's procurement and use of hardened vehicles. Responding to a specific need to answer the elusive question, "How much is enough?," the CTA has been providing tactical vulnerability analysis training programs designed to enhance onsite protection planning for safeguards and security improvements. The CTA has proven to be an extremely valuable asset to the Department in its short period of existence. Because of the top notch quality of its faculty, CTA advice and methods are much sought after by other Federal agencies as well as state and local law enforcement organizations.

The Department submitted a legislative initiative last year which requested that section 161.k of the Atomic Energy Act (42 USC §2201(k)) be modified in such a way as to ensure that our contractor protective force personnel would have sufficient legal authority to carry firearms and pursue a "fleeing suspect" beyond the boundaries of a DOE facility. Concerns had surfaced that section 161.k (the legal authority under which a DOE contractor protective force officer may carry a firearm and make arrests) might be insufficient in "hot pursuit" situations. The necessary amendments to section 161.k. were included in the Department of Defense Authorization Act, 1987 (P.L. 99-661).

Physical Fitness for Security Inspectors

As you may be aware, the Department issued a final rule in November 1984 which established mandatory physical fitness and medical standards for our security inspectors. This rule, 10 CFR Part 1046, sets forth minimum medical and physical fitness requirements for all DOE security inspectors which had to be met within 1 year (December 1985). The physical fitness requirements were met throughout DOE's facilities with a 97 percent success rate. This was a remarkable achievement. Thereafter, the Department issued a modification to 10 CFR Part 1046 which requires security inspectors to maintain their fitness levels by participating in locally developed physical training programs on a continuing basis. This better enables our protective force personnel to meet the requalification requirements (every 12 months), and ensures that a measurable level of fitness is being maintained. I am happy to report that this program has proven to be a great success by ensuring that those individuals assigned to protect DOE's most sensitive facilities have the ability to perform their duties under emergency conditions.

Nuclear Material Control and Accountability

The Department's initiatives and programs over the past few years to support site-specific safeguards and security improvements have emphasized large-scale, state-of-the-art perimeter intrusion detection and assessment systems, surveillance equipment, and improved guard force response capabilities. Aided by improvements in measurement technology and data analysis techniques, nuclear material control and accounting practices are now being increasingly emphasized at key DOE sites to identify improvements that will help address concerns such as special nuclear material diversion that might be masked by measurement uncertainties or falsification of data. Nuclear materials measurements and related control programs are vital to effective safeguards in meeting the needs of detection and confirmation that no diversion has occurred. The Office of Safeguards and Security is sponsoring efforts at DOE national laboratories and the DOE New Brunswick Laboratory to assure that all potential avenues of material flow across material balance areas within the DOE complex are controlled and accountability maintained.

Classified Document Control, Accountability, and Inventory Reduction Initiative

As a result of recent preliminary indications that classified document control throughout DOE needs improvement, we have initiated an internal review of practices in the control and protection of classified information and documents. Requirements for control of Restricted Data are contained in the Atomic Energy Act of 1954, as amended, and Executive Order 12356 contains requirements for control of National Security Information. Implementing procedures are set forth in DOE orders. A number of DOE sites are being visited to review controls and to gather information and data for an overall Headquarters analysis. Results will be used to identify areas for potential improvement and to develop a strategy for continuing systematic assessment of the classified document control program.

Computer Security Initiative

The past few years have witnessed unprecedented expansion in computer technology which provides vital support to the nuclear weapons program. Past decentralized practice has resulted in wide variations in the level of security for the Department's classified computing systems. Our goal is to assure the necessary level of computer and communications security while maintaining as much ease of use as can be accommodated to facilitate the maximum productive output. One of the first management steps to bring uniformity and upgraded levels of protection will be full implementation of a new computer security program policy. This policy embraces current advances in technology and provides a reasonable approach to upgrading extant technologies and procedures in order to improve the overall efficiency and effectiveness of secure computing in the DOE complex. We have embarked on an intensive education and training program to enhance the skills of computer security personnel and computer security awareness of other personnel. This program of education and training is one of several activities of the DOE Center for Computer

Security. Full implementation will include a short- and long-range national planning process which will provide the information to increase resource utilization and improve management direction.

The computer security program will continue to test and monitor the security measures being implemented on the Wide Band Communications Network. This network will provide the capability to exchange nuclear weapons information between the design, testing, and manufacturing sites. The development and testing of the security features for the network is a continuing activity of the DOE Center for Computer Security.

As computer technology has advanced, there has been a marked increase in the requirement for the exchange of information between computers. The DOE Center for Computer Security continues to be involved in the research, testing, and monitoring of the methods and technology to provide security for this exchange. Additionally, the center is responsible for the design, development, and implementation of computerized methods for the identification and analysis of computer vulnerabilities.

Personnel Clearance Program Management Initiatives

Our personnel security program initiatives include a major effort to reduce the numbers and levels of DOE clearances. This initiative began after we determined that many individuals involved in non-Defense Programs related work had been processed for clearances at a level higher than needed for their official duties. This initiative will not hamper the effectiveness or efficiency of Defense Programs activities but will result in the proper levels of clearance being granted for all individuals who require a DOE clearance and eventually will enable us to concentrate our personnel security program resources on those individuals who actually require a clearance in connection with their duties. Concurrent with this initiative, we upgraded our reinvestigation requirements in December 1985 and now require periodic reinvestigations for all individuals who have a DOE clearance. This new requirement is being stringently applied throughout the Department, and we anticipate full compliance within the next 5 years. As this new requirement requires additional effort on the part of our personnel security staff, we have taken steps to augment current staff at Headquarters and field offices with contractors and other agency detailees. To assure proper training in adjudication techniques and consistency in the application of our clearance criteria, we have increased our training efforts of staff, contractors, and detailees. Other initiatives in this arena include implementing, DOE-wide, the already operational classified visits control system which uses computer base transmission of classified visits requests. This is done while cross-checking the clearance information with our computer base clearance records system, and continuance of our efforts to review and update our computer base clearance records to assure timely and accurate data.

The Department has had a variety of mechanisms to address its increasing concern over an increasing potential "insider" threat. In its time, each effort has been successful; however, as our society changes and becomes more permissive, the potential for an adverse "insider" incident increases. Accordingly, the Department expanded on an ongoing effort to design a Human Reliability Program (HRP) that would assure that employees in certain identified positions continue to display sound judgment. This program addresses and reduces the increasing potential insider threat through periodic monitoring of both DOE and contractor employee reliability, and referral of potential problems to the occupational medicine and employee assistance programs for possible rehabilitation. An HRP Task Force was created to address and develop agency regulations, directives, and implementation guidelines which were staffed with Headquarters, field office, laboratory, and operating contractor personnel with expertise in a broad variety of human quality assurance disciplines. A Center for Human Reliability Studies (CHRS) was established to assist in providing specialized expertise in various fields related to the HRP development and implementation. An informal observers group, formed from other Federal HRP-like programs, was established to share concerns about and solutions for HRP implementation problems. Our goal is to have a Departmental HRP become a reality in FY 1987.

Planning

A viable and forward-looking strategic and operational planning process is critical to assuring cost-effective application of safeguards and security within the Department. The OSS has, therefore, concentrated on expanding and formalizing its planning process. One of the more important aspects of our planning strategy is the Master Safeguards and Security Agreement (MSSA) program. The MSSA establishes a field office/Headquarters binding agreement regarding the level of protection for each of our critical facilities taking into account site- and program-specific conditions and achieving a balance between inherent risks and incremental costs associated with protection measures. Six MSSA's have been completed, and approximately 20 others will be completed this fiscal year. As a follow-on, a forward-looking 5-year planning process is currently under development by the OSS. The process is being designed to use the MSSA for each facility, which contains the acknowledged levels of risk for each target as the baseline guidance for the 5-year planning projection of needs, costs, and system performance at each facility. The MSSA program and 5-year planning process both make use of the standardized tactical vulnerability assessment program that is currently being taught at the Department's Central Training Academy.

We recognized that there is a direct correlation between the effectiveness of our safeguards and security programs and the quality of our safeguards and security policy. With this in mind and the ongoing development of the Department's safeguards and security standards and criteria, increased emphasis has been placed on assuring that DOE safeguards and security policy is both current ~~and~~ all encompassing. During FY 1986 DOE orders in the computer security, operations security, security awareness, and personnel clearances areas were revised. A task force is currently being organized to further assist OSS in assuring identified policy voids or additional needed revisions to policy guidance ~~are~~ expeditiously handled.

Classification Management Initiatives

In support of the goal to maintain credible, up-to-date, and operationally practical classification policies and guidance, the Office of Classification's

FY 1987 support activities focused on continuing active support for technical studies and analyses in such areas as inertial confinement fusion, computer codes, nuclear weapons testing, uranium enrichment, and safeguards and security. In addition, major program efforts continued for the review of sensitive nonnuclear technologies, including Strategic Defense Initiatives (SDI). Substantial progress was made in the development of classification education materials, appraisal training, and quality assurance procedures. A major new program effort was initiated to develop policy and guidance for the identification and protection of Unclassified Controlled Nuclear Information (UCNI) and other categories of unclassified controlled information. Substantial progress was made in international classification coordination efforts with the final development and implementation of the NATO ATOMAL Guide and Classification Management program.

THE BUDGET

The Nuclear Safeguards and Security Headquarters oversight program's budget request for FY 1988 is $77.8 million. Operating expenses require $73.2 million, and capital equipment $4.6 million. For FY 1989, the budget request is $83.4 million.

The safeguards and security Headquarters program strategy directly supports oversight and research and development activities. Oversight activities include: technical assistance to address vulnerabilities identified by onsite evaluations, protective force training, and nuclear materials control and accounting. Also the Office of Safeguards and Security oversees the Federal New Brunswick Laboratory. Research and development activities include a unique nationally available technology base on physical protection, materials control, and nuclear materials accounting systems. This research and development technology base is conducted by the national laboratories for application by the Department's field operations and other Federal, state, and local agencies. We appreciate past congressional support for the construction of the Nuclear Safeguards Technology Laboratory at Los Alamos, New Mexico, which we consider important to the development of improved nuclear materials control and accountability. The FY 1987 budget supported design work, but construction has been eliminated in the FY 1988-89 budgets to meet the Gramm-Rudman deficit targets and to avoid disruption of ongoing high priority work. This does not mean there is no need for the facility. Simply put, we could not afford the mortgage.

This safeguards and security request does not fund the construction, capital equipment, and operating expenses of safeguards and security systems at DOE field facilities. These costs are budgeted for and expended by the Department's outlay programs, which include the nuclear weapons, nuclear materials production, and the civilian nuclear energy and energy research programs.

Mr. Chairman, the FY 1988 request of $77.8 million consists of the following five basic elements which I will address. These include: safeguards and security operations, technology development, international safeguards, classification, and program direction.

SAFEGUARDS AND SECURITY OPERATIONS

This category supports the Headquarters oversight mission of protecting Departmental resources, which range from completed nuclear weapons to classified documents. At the heart of the oversight program is a uniform systematic approach to safeguards and security programs which can assure that proposed solutions are both effective and efficient.

Elements in this category involve three major functions: guidance and assistance to DOE field operations for safeguards and security system improvements; oversight of the nuclear materials management and safeguards system, which provides timely data on nuclear materials production, utilization, transfer, tracking, and storage; and the operation of the New Brunswick Laboratory, the safeguards analytical laboratory at Argonne, Illinois.

Over the past few years, at no small expense, we have corrected deficiencies at DOE facilities. Field managers applied state-of-the-art, large-scale hardening features; surveillance equipment; and have dramatically improved guard force response capabilities. I believe the Department has made DOE sites unattractive targets to any adversarial force.

In my view, we must now seek to balance the protection systems in place against outside adversaries with an effective program against the "insider." We must now undertake the difficult chore of protecting these critical national assets against potential perpetrators who may actually have access to our facilities. It is not pleasant to talk about. I do not like it, but, like it or not disaffected or disgruntled employees, visitors, and assignees do exist. Because these elements exist, we must have programs to deal with them. We are pursuing several major management initiatives that comprise an integrated protection program against insiders. Key elements include: personnel clearance, human reliability, physical protection, information and document control, operations security, security awareness and education, intelligence community liaison, foreign travel/alien visits and assignments, and nuclear material control.

I have already touched upon initiatives in personnel clearance, human reliability, elements of physical protection, and document control. In recognition of the hostile intelligence threat to classified or sensitive unclassified DOE technologies or facilities, we will continue to maintain a strong operations security, or OPSEC, program. OPSEC is a key ingredient in our overall security protection program and is fully integrated both at Headquarters and all field elements. The Office of Safeguards and Security (OSS) has provided sufficient training for field personnel to conduct their own OPSEC vulnerability assessments and this process is well underway. Identified vulnerabilities are analyzed, countermeasures are developed, and their implementation is prioritized all at the local level. The OSS ensures the effectiveness of this program through an oversight management process.

We will continue to operate and expand our Security Education and Awareness program. This program was substantially improved in FY 1987 through revised policy establishing new requirements to strengthen the DOE program and implement new national policy. FY 1988-89 expansion will include analyses in such areas as the human reliability program, foreign travel and visits and assignments activities, and insider and outsider threats, to determine appropriate changes which may be required in Security Education. We will continue conducting workshops and seminars, and providing educational materials throughout the DOE.

The Department has implemented NACSI 5004 in the TEMPEST program and will continue to control compromising electromagnetic emanations through a variety of countermeasures, including the use of zone tests. We will also continue the development of advanced technical surveillance countermeasures and suppression technology in support of the Intelligence Community technical security operations.

Central Training Academy

Advanced special weapons and tactics training, with a particular focus on realistic tactical situations, continues to be a critical ingredient in improving the capabilities of our protective forces. We are using our Central Training Academy (CTA) to provide uniform training standards and to improve supervisory effectiveness throughout DOE. The CTA instills a uniform and professional approach to protective force training in the tactical, operational, and technical aspects of physical security. The curriculum at the CTA will be expanded in depth and scope to certify instructors and training officers, to train tactical vulnerability assessment officers, and a variety of other security discipline subjects and functions not being taught outside the Department of Defense. In FY 1985, the CTA provided training to about 1,300 DOE employees and contractor personnel. In FY 1986, training was provided to approximately 2,800 individuals, while in FY 1987 we project training for 1,800 personnel. The reduction in FY 1987 reflects completion of the initial round of training to implement DOE policy on arrest authority and use of deadly force.

Nuclear Material Management and Safeguards System

We will continue to operate the DOE's Nuclear Materials Management and Safeguards System, supported jointly with the Nuclear Regulatory Commission. This system, the Nation's single nuclear materials computerized data base, is used to track nuclear materials in the United States and to record the shipment of nuclear materials to and from foreign countries. Each year, approximately 78,000 nuclear material transactions (e.g., approximately $10 billion in nuclear shipments, receipts, and inventory changes) from 130 contractors and about 900 licensees are entered into this system and tracked.

New Brunswick Laboratory

This budget funds the New Brunswick Laboratory (NBL) which serves as the U.S. Government standards laboratory for nuclear materials measurements. NBL also provides control and accounting services to DOE field offices and contractors in order to fulfill safeguards requirements. Its functions include: measurement services in support of Government audit and inspection requirements; assessing and evaluating measurement technology in support of DOE fuel cycle and weapons production activities; developing, certifying, and distributing reference materials for calibration and standardization of materials measurements; and assisting in technology exchange and training in measurement technology.

TECHNOLOGY DEVELOPMENT

Technology development continues to be an integral part of our safeguards and security program since advanced technology is necessary for better control and accountability of nuclear materials, better physical protection techniques, and other protection techniques. Research and development (R&D) conducted by the national laboratories provides DOE with a technological base for developing new systems for safeguarding the Department's nuclear facilities and materials. Results of these efforts are also made available to the Nuclear Regulatory Commission and its licensees, as well as other Federal agencies.

Before I detail what we are doing in our small R&D program, I want to indicate that I see a problem developing because of fiscal constraints that could cause serious erosion (and in fact loss) of the security technology hardware and manpower base at Sandia National Laboratories. Unless the trend of the past 4 years is reversed, DOE facilities requiring improvement and other departments and agencies that have been depending upon this unique national laboratory expertise will find themselves powerless to quickly (or completely) replace what is steadily being lost due to funding shifts and constraints. From FY 1984 through FY 1987, Sandia funding has been reduced by over 50 percent.

Even though our research and development activities are coordinated with other agencies, the Nuclear Regulatory Commission and the Department of Defense, in particular, through the Safeguards and Security Steering Group and staff-level liaison, the technology erosion problem will get worse unless we rebuild the technology base and urge other agencies that are benefiting to increase their share of funding. Joint research efforts of mutual benefit are identified in order to reduce the costs of such activities to each agency, and we will continue to emphasize this coordination of research and development to further minimize costs.

An integral element of the R&D planning, programming, and budgeting process is assessment of near-term and future risks, with the aim of investing in a development strategy that keeps risks at an acceptably low level. Such an assessment must take into account the spectrum of threats (i.e., the full range of characteristics and resources as opposed to separate focus on the "outsider" and the "insider"), including the trends and directions of change in the threats. DOE has taken steps to improve the leverage of R&D and the technology base for enhanced capability to mitigate the threat to DOE facilities. These steps encourage preplanned and affordable improvements. The basic strategy for R&D is a program that: (a) is oriented to user needs; (b) is relevant to DOE safeguards and security objectives and overall policy; and (c) minimizes the cost of implementing safeguards and security systems.

In addition to solving a problem and enhancing safeguards and security capabilities, evaluation criteria includes a factor that a proposed R&D project (user-need statement) should offer potential reductions in operational outlay ("crosscut") budgets for safeguards and security. Proposed R&D projects must meet the evaluation criteria to be given a high priority for funding. This provides an incentive and leverage to improve both effectiveness and efficiency of the overall safeguards and security mission, and requires close coordination with outlay programs and designs to influence and provide timely performance expectations and cost-effectiveness for new DOE facilities and processes.

INTERNATIONAL SAFEGUARDS

Our international safeguards program supports U.S. nonproliferation and national security objectives to minimize the proliferation of nuclear weapons. The activities of program staff and contractors are required by the Atomic Energy Act of 1954, the Nuclear Non-Proliferation Act of 1978, the Omnibus Diplomatic Security and Anti-Terrorism Act of 1986 and implementing Executive Orders and Presidential directives. The primary objective is to strengthen international safeguards and physical protection through technical support to the International Atomic Energy Agency (IAEA) and cooperative efforts with other nations. Research and development will continue on new and improved technologies and systems for IAEA safeguards, including efforts on safeguards for reprocessing plants and for mixed-oxide (plutonium and uranium) fuel fabrication plants. These efforts reflect the increasing use of plutonium as fuel in civil nuclear fuel cycles. An important aspect of our research and development is increased bilateral cooperation, including technical exchanges with the Federal Republic of Germany, France, and the United Kingdom, as well as the inspectorate of the European community. These bilateral efforts optimize the research and development efforts of the U.S. and other nations through exchanges of information, staff, and equipment on international safeguards and physical protection of nuclear materials. Additionally, the application of the atomic vapor laser isotope uranium separation (AVLIS) process for enrichment introduced a new requirement for development of international safeguards methods and equipment for use with AVLIS under the U.S./IAEA agreement for the application of international safeguards in the U.S.

Beginning in FY 1989, increased funding will be required to permit resumption of deferred R&D and the establishment of nonproliferation safeguards cooperation with Japan, Argentina, and Brazil. This increase in funding will also permit the Department to continue its responsibility to train foreign personnel in the most advanced safeguards and physical protection techniques.

Compliance with international agreements and nonproliferation objectives requires that we monitor certain international shipments of U.S.-origin materials and tracking of foreign origin materials in the U.S. Other continuing activities include recording exports, imports, and transfers of materials of foreign origin in the U.S.; reporting to the IAEA under the U.S./IAEA Safeguards Agreement and other agreements; and determining inventories of nuclear materials for bilateral agreements for cooperation.

CONSTRUCTION

The Nuclear Safeguards Technology Laboratory (NSTL) ($10.6 million TEC) that was to be located at Los Alamos would have improved our research and development effort in the safeguards and security technology area. In FY 1987, an appropriation of $1.0 million provided for building design and construction of an access road. This project has been eliminated from our request due to funding constraints.

PROGRAM DIRECTION

Our program direction supports a total of 146 Headquarters full-time equivalent positions, which includes the staff for the classification program.

CLASSIFICATION

The FY 1988 request for the Classification program, which is incorporated in the Nuclear Safeguards and Security program budget, is $4.5 million. The FY 1989 Classification program will continue at the FY 1988 level of effort. The Office of Classification manages and implements the Department's program for the classification, declassification, and control of information in the interest of the national security.

The FY 1988 request will continue active support for the review of potentially sensitive DOE research and development activities, as directed by National Security Decision Directive-189 (NSDD-189) and for classification development and oversight activities in program areas involving sensitive technologies including Strategic Defense Initiatives, nuclear testing, and other nuclear weapons areas. In addition, international coordination efforts will continue with the implementation and monitoring of NATO ATOMAL classification functions. Efforts will continue on policy development for the identification and protection of Unclassified Controlled Nuclear Information and other categories of unclassified controlled information, as well as concentrating guidance development efforts in such areas as computer codes, isotopes separation, and safeguards and security. Support will be provided for enhancement of classification education and training efforts. Efforts will continue on expanding operation of a computer data base of classification guidance. Continuing support will be provided for Classification's appraisal, quality assurance, and document review programs.

SECURITY INVESTIGATIONS

The FY 1988 request for personnel security investigations is $32.0 million. Background investigations are required by the Atomic Energy Act of 1954, as amended, and by Executive Orders 10450 and 10865. The Department is not permitted to conduct its own investigations; hence, we rely on and reimburse the Federal Bureau of Investigation (FBI) and the Office of Personnel Management (OPM) for conducting investigations of DOE employees, contractor employees, and consultants assigned to critical sensitive positions prior to their being granted access to classified information, classified materials, or special nuclear materials.

In order to have efficient program management and be consistent in meeting security requirements, we use this single program to meet the strict requirements of the Atomic Energy Act of 1954 to ensure that granting access to classified information, classified material, or special nuclear material will not endanger the common defense and security. Most background investigations directly support Defense Programs since the Department believes any clearance or access determination is directly related to protecting the common defense and security. The DOE is currently reviewing access authorization levels and lowering many Q-"Sensitive" access authorizations requiring an FBI reinvestigation to Q-"Nonsensitive," requiring an OPM reinvestigation.

During the last year, the OPM has made a significant effort in reducing the time required to conduct a background investigation. OPM is currently completing new investigations in approximately 110 days. OPM has recently obtained approval to hire an additional 180 investigators. With the additional investigators and the close out of their private sector contractor investigator effort, OPM hopes to reduce the investigative times to 90 days during FY 1987.

The additional investigators will allow OPM to meet the demand for additional investigations required under the revised DOE Selective Reinvestigation Program requirements. These requirements, which the DOE is in the process of implementing in FY 1987, stipulate that all individuals who have a DOE clearance must be reinvestigated every 5 years. Of course, the scope of the reinvestigation will depend upon the level of clearance held by the individual. Based upon the current number of individuals who have an active DOE clearance and who have not been reinvestigated in the last 5 years, about 97,000 reinvestigations must be conducted over the next 5 years. We plan to request about 20,000 reinvestigations per year for the next 5 years to comply with our new requirements in addition to the investigations that will be scheduled for initial clearance action and for reinvestigation in the normal course of program operation.

Our FY 1988 budget request provides for 29,426 initial full-field investigations and National Agency Checks with Credit (FBI-1,000, OPM-28,426) and 11,000 reinvestigations. In FY 1989, the full-field investigations will remain at FY 1988 levels and reinvestigations will increase by approximately 12,600.

SAFEGUARDS AND SECURITY CROSSCUT

As I mentioned earlier, the DOE outlay programs fund safeguards and security activities at the Department's field facilities. Total safeguards and security funding is approximated in the Department's crosscut estimate, which is a rough summation of all safeguards and security items in the Department's program requests, including the budget for the Office of Safeguards and Security. The crosscut estimate for FY 1988 totals $809 million, with $702 million as the defense activities portion.

As the Departmental coordinator for all DOE safeguards and security activities, Security Affairs has a range of responsibilities for safeguards and security crosscutting activities which include ensuring that program budget submissions properly reflect judgments that have been made with respect to security considerations. For example, the major construction upgrades at critical nuclear weapon facilities, such as Savannah River, Pantex, and Oak Ridge, which provide enhanced integrated protection programs against the Department's defined threats, were fully coordinated with and recommended for approval by Security Affairs. We validate the need for safeguards and security improvements, evaluate proposed upgrade designs for adequacy, and verify the performance of the upgrades once they are in place. This process is critical if we are to assure continued protection system progress in upgrading our critical facilities, and effective safeguards and security integration. Significant progress has and continues to be made towards increasing the level of protection of our facilities and the protection of DOE assets. A good portion of this has been accomplished through guard-intensive, quick-fix measures. The validation of major construction projects designed to provide long-term permanent corrective action to vulnerabilities is critical to assuring effective safeguards and security integration and the replacement of existing systems with more state-of-the-art hardware and software protective measures. If this is not accomplished and supported, our safeguards and security program will be in jeopardy.

I would now like to discuss the FY 1988/FY 1989 budget request for Verification and Control Technology.

VERIFICATION AND CONTROL TECHNOLOGY

The Verification and Control Technology (V&CT) program within DOE contains both technical and policy elements. Perhaps the most common thread among the policy program elements is the requirement for flexibility necessary to focus the resources of each program element upon immediate or near-real-time issues. The technical research and development program is the basis for much of the United States' arms control treaty verification capabilities related to nuclear issues.

Program Detail

The Office of International Security Affairs provides staff and programmatic management for the international security functions of current and potential arms control treaty verification and nuclear nonproliferation controls. These functions include:

- The development of verification technology and production of systems to monitor foreign nuclear explosions to verify compliance within treaties that constrain such explosions, and to monitor foreign nuclear activities. This activity supports:
  - Development of administration policies toward verifiable arms control treaties,
  - Technical guidance for arms control negotiations,
  - Confidence building measures,
  - Cooperative, onsite monitoring, and
  - National technical means (NTM) of verification for the Intelligence Community.
- The control of nuclear and energy-related exports and the transfer of strategically significant technologies in accordance with legislative mandates and U.S. national security and nonproliferation policies.

The objectives of the arms control program of applied research and policy support are: to continue to support interagency and international policy deliberations and negotiations, to provide programmatic support for improvement of arms control techniques and approaches, and to maintain the capability to supply technical support in the arms control arena. To meet these objectives, our work program is divided into three categories: studies and analyses of current active issues, studies directed toward future issues, and quick-reaction response to current issues. The in-house staff and selected expertise from the National Laboratories and contractor support allow us to bring to bear the best expertise in the nation on problems associated with these issues.

Arms Control Program

Among the most important policy activities is the implementation of the Administration's arms control policies as communicated in the President's National Security Decision Directives and other sources. Other sources include arms control policy deliberations and U.S./Soviet arms control negotiations and technical discussions. The Office of International Security Affairs (OISA) provides both policy and technical experts to U.S. strategy option deliberations, bilateral and multilateral negotiations and technical meetings.

The overall objective of OISA's verification research and development is to provide both technical and policy support to the national security needs for arms control, verification, and intelligence. This is accomplished through a program of long-term technical research and development of technologies, development of equipment and methodologies to support near-term verification requirements, and resolution of technical issues. The program contributes to both the development of improved national technical means of verification and onsite monitoring techniques to assist in verification of compliance with arms control treaty constraints.

Included in the development of improved national technical means are techniques for the detection, identification, characterization and location of nuclear explosions in all environments: underground, underwater, in the atmosphere and in outer space. The onsite monitoring activity, among other things, also develops the capability to monitor compliance with the yield constraints of the Threshold Test Ban (TTB) and Peaceful Nuclear Explosions (PNE) Treaties. Discussions are underway with the Soviets concerning possible changes to the Threshold Test Ban Treaty to include onsite monitoring. Should these discussions be successful, the uncertainty of yield estimates of Soviet underground explosions could be reduced significantly. The DOE's role in this area is defined in National Security Decision Directives (NSDD) 51, 63, and 81. These Presidential decision memoranda direct that the verification community take policy and technical actions designed to improve the verification of treaties limiting underground nuclear testing. The Verification and Control Technology (V&CT) program is charged with providing modern equipment, manpower, expertise and a full range of capabilities to permit the U.S. to fulfill its PNE and TTB Treaty verification responsibilities. DOE has developed and evaluated hydrodynamic yield measurement (Continuous Reflectometry for Radius versus Time Experiment, CORRTEX) as a monitoring technique. CORRTEX would be combined with a complementary local seismic network and a trained personnel cadre for onsite monitoring. This program is also responsible for support of the Joint Technical Experiment with the USSR related to onsite monitoring proposed by the President in 1984, should we reach agreement with the Soviets for implementation of such a program.

Seismic verification continues to focus on the detection, identification, location, and characterization of underground nuclear explosions, emphasizing regional rather than teleseismic monitoring. Our program is working on in-country seismic R&D for developing seismic verification capability at regional (short-range) and local distances. This emphasis is to ensure that DOE can fulfill any national decision to provide equipment and systems to support U.S. verification of any future treaties. An example of technology developed under our program is the regional seismic array approach that is embodied in the Norwegian Regional Seismic Array. The objective is to reduce the error range of yield estimates of nuclear tests Deleted by using additional regional arrays, in support of more effectively verifiable arms control agreements. A Deployable Seismic Verification System (DSVS) is in work. Any future treaties that further constrain nuclear testing will depend on such a capability to assure the USSR's obligations are being complied with.

In addition to its verification efforts for treaties constraining nuclear explosions, the program develops gaseous and particulate radioactivity monitoring systems for sample/debris detection and analysis activities. Collection and analysis of fresh radioactive debris provides the only unambiguous evidence of clandestine nuclear activities, an area of increasing concern in the current environment where third-world countries are developing their nuclear capabilities. The result of this effort will be monitoring facilities with high sensitivity, onsite analysis, and real-time telemetry of data provided to a central monitoring facility.

Other monitoring activities include research and development of means for detection, other than optical and seismic, of nuclear detonations. Seismic nuclear explosion verification activities are long standing and seem to be approaching maximum levels of capability for any particular seismic range. Nonseismic means of detecting nuclear explosions - especially for a possible lower yield threshold - are essentially nonexistent. Because of the vast area of the Soviet Union that is seismically active and the potential for treaty evasion that activity offers, other technical means of monitoring nuclear explosions require investigation. These means would complement existing or developmental seismic verification capabilities.

Directed energy weapons (DEW), both ground-based and in space, are of increasing interest. *Deleted* *Deleted* Some of their DEW's may employ nuclear-driven devices. Therefore, research must be conducted on techniques for monitoring these activities. These monitoring activities are the result of the demand for technical intelligence on Soviet experimental and/or operational systems using SDI-type technology. Our program supports documented requirements for characterization of all DEW systems; and, as a natural outgrowth of these characterizations and our laboratories' expertise in these disciplines, sensors, systems, and data handling, processing, and analysis capabilities are being developed. Ongoing work also concerns a viable satellite attack warning system (SAWS) to protect U.S. satellites from foreign attack.

Our program activity also supports national verification technology. Technology includes the fabrication of equipment (sensors and systems), and analysis and data reduction and evaluation. We also seek to define new systems, for example, those that might be required for monitoring DEW activities as discussed above.

Under the satellite instrumentation program, we fabricate satellite sensor payloads and participate in the national effort that uses satellite-borne sensors to monitor the atmosphere and space for nuclear explosions. Satellite-borne sensors provide monitoring of compliance with the Limited Test Ban Treaty (LTBT) and also support intelligence data collection on potential proliferating nations and on nuclear weapon states that are not LTBT signatories. The DOE laboratories, under contract to the Air Force, also provide the systems and capability to detect and locate multiple atmospheric nuclear bursts in a battle management situation.

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These DOE-produced sensors provide worldwide surveillance and intelligence monitoring of atmospheric and exoatmospheric nuclear explosions to deter clandestine testing by the Soviet Union, or by nations developing a nuclear weapon capability.

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The DOE's responsibilities in export control and technology transfer follow from statutory requirements and Executive Orders. The DOE is one of a number of agencies involved in the regulation and control of technologies, material, facilities, and component exports that relate to U.S. material security and nonproliferation interests. In addition to providing operational support to other agencies in the export licensing process, OISA authorization is required on DOE authorized transfers and licensed exports by the Nuclear Regulatory Commission, Department of Commerce, and Office of Munitions Control. In this connection, OISA must maintain the capability to review and process in a timely fashion more than 10,000 export license applications annually in support of the Department of Commerce.

In the area of transfer of sensitive nuclear technology, OISA has developed and implemented revised procedures and orders for processing foreign national visits and assignments and will continue to review these requests as well as foreign travel of DOE and DOE contractor personnel to sensitive areas. OISA will also continue the support revision of the Militarily Critical Technologies List (MCTL), with special emphasis on SDI-related technologies. We will also continue to participate, as required, in the interagency working groups, committees, and panels that address the technical and policy issues associated with technology transfer.

PROGRAM INITIATIVES

The budget request for FY 1988 ($101M) is 4% greater than the V&CT budget for FY 1987 ($97M). The FY 1989 budget request ($132M) on the surface appears to represent a major growth in the V&CT budget. In fact the $31M increase actually contains only a 6.5% increase in the FY 1988 budget. The remaining $22.5M (93.5% of $31M) supports initiatives in verification and control technology activities in support of arms control initiatives.

This technology development which supports arms control initiatives is only possible on this time scale due to the depth of capability within the V&CT program. The onsite verification effort planned for FY 1989 builds upon the hydrodynamic yield measurement experiments and computer modeling that have been a part of the verification efforts over the past several years. Specifically, this work is planned ($3.2M) to address the problem of reducing the estimation error range deriving from the CORRTEX measurements. This directly supports the Nuclear Testing Experts meetings in Geneva and negotiations for improvements in the yield estimates of underground nuclear explosions.

The Department through the V&CT program has an ongoing, long-term R&D effort in explosion seismology. This has supported the national capability to detect, identify, locate, and characterize underground explosions. The new initiative in seismic verification while not directed explicitly at the present discussions of Threshold Test Ban Treaty can be vital for in country reduced yield agreements in the future. The V&CT program has developed and engineered deployable systems in the past to support verification of treaties constraining nuclear explosions. These have included the in-country regional seismic system developed during the Carter Administration's negotiations for verification of a Comprehensive Test Ban Treaty and a local seismic network to support the Protocol to the Peaceful Nuclear Explosions Treaty.

The in-country regional seismic network was designed a decade ago. Hence its capability is fixed by the technology that was available at that time. In early FY 1986 the V&CT began planning and programming for a deployable, state-of-the-art seismic system, called the Deployable Seismic Verification System (DSVS). The DSVS program underscores deployability using off-the-shelf proven technology. Presently the V&CT program is designing and initiating fabrication of such a DSVS. The FY 1989 budget is designed with a significant input to this effort ($9.2M) in order to make significant progress.

Since the signing of the Threshold Test Ban Treaty and the Peaceful Nuclear Explosives Treaty, the DOE has had the responsibility of supplying equipment, capability, operations plans and personnel to meet the U.S. obligations for onsite verification fixed under the protocols of those treaties. During FY 1988, the V&CT program will conduct an exercise at the Nevada Test Site which will utilize the equipment, demonstrate capability and train the cadre of U.S. personnel.

An integral portion of the efforts within the V&CT program consists of exploratory studies evaluating the possibilities of advanced verification technologies. These include the exploration of the application of specific physics, for example, infrasound and radar monitoring, development of new instrumentation, and evaluation of advanced means of data interpretation. These efforts are possible because of the technical capabilities of the national laboratories. The increases in the FY 1989 budget for advanced concepts in verification ($3.8M) will support a number of initiatives for preliminary investigation at the national laboratories.

The V&CT program continues to make investments in research in order to increase future capabilities in verification technology. These research activities are pursued without the constraint of delivering a system to a specific user or meeting the requirement for verification of a specific arms control treaty.

Deleted

The program initiatives that have been described here are those that will have significant impact on budget formulation. In FY 1988 and FY 1989 these all fall within the development of verification technology and production of systems to monitor foreign nuclear activities and to verify treaty compliance. Additionally, the program has a number of new initiatives relative to the control of nuclear and energy-related exports and the transfer of strategically significant technologies. These, however, are not described here as budgetary impacts because they are small.

This completes my statement. I will be happy to respond to any questions.

DEFENSE PROGRAMS MISSIONS

Mr. FOLEY. The Defense Programs missions haven't changed at all. Quite briefly, they are to support the nuclear deterrent, provide safeguards and security for nuclear weapons, materials, and facilities, and provide safe and environmentally acceptable operations of these facilities.

DEFENSE PROGRAMS PRIORITIES

What are the priorities in doing this?

DEFENSE PROGRAMS' PRIORITIES

- MAINTAIN BASIC CAPABILITY & CAPACITY
  - —FACILITIES (WITH CONTINUED RESTORATION, REVITALIZATION, AND MAINTENANCE)
  - —RD&T TECHNOLOGY BASE
  - —ESSENTIAL SAFEGUARDS AND SECURITY
  - —CONTINUITY OF OPERATIONS—ES&H
- SUPPORT NWSM REQUIREMENTS
  - —WEAPONS DEVELOPMENT AND PRODUCTION
  - —NUCLEAR MATERIALS AVAILABILITY
  - —SUPPORT ACTIVITIES
- STRATEGIC DEFENSE INITIATIVE MILESTONES
- IMPROVEMENT EFFORTS

First of all, to maintain the basic capability and the capacity at our facilities. You have heard me testify in the past on the fragility of this entire complex and the need to restore it, revitalize it, and keep up with the maintenance of it. We need to maintain our technology base, our safeguards, our security, our continuity of operations, and do all of this in an environmentally safe manner.

This is fundamentally the basic capability and capacity and my No. 1 objective. Of course, the No. 1 research and development priority that we have is General Abrahamson's Strategic Defense Initiative [SDI]. But the basic capability and capacity of the entire complex is to fundamentally support the nuclear weapons stockpile requirements. This is our Bible signed out by the President—the weapons development, the production, the materials availability, and the support activities that go along with this.

Let me get up and talk to these viewgraphs. This will give me a better chance to wave my arms and get the flavor of things across to you as we go along, sir.

PROGRAM IMPROVEMENTS

With respect to improvement efforts in the last year, one of the things we have done is to put some planning into the defense programs. In my judgment, we responded to the budget, though we did very little long-term planning and not much medium-range or short-term, 5-year planning. We now have a structure in place and we parallel our 5-year defense programs budget with the Department of Defense. We call ours a Five Year Program Analysis, but it is the same thing. The track goes on for 5 years. Then we ask ourselves, what do we want the complex to look like in 15 years? What kind of preparation, what kind of facilities will we need after the turn of the century? We do not want to respond just to the budget because there is no planning document. You have to make conscious decisions based on that budget and know what the impact is going to be. That is the long-range planning we need to give us some vigor as the century turns.

We have put this in place. We have also brought in all of our field managers and laboratory directors, and we set down around the table. These individuals are our senior management group. We wrestled with the budget, but we did it in a collegial fashion. We make all of our decisions that way. When you go home you may not be totally satisfied, but you have played in the process, and you know your place in the entire structure of the defense programs.

DEFENSE PROGRAMS
FY 1988 CONGRESSIONAL BUDGET

INCLUDES:

- SUPPORT FOR NUCLEAR STOCKPILE MEMORANDUM
- SUPPORT DOD MILESTONES FOR NUCLEAR DIRECTED ENERGY WEAPONS
- CONTINUE LONG RANGE FACILITIES REVITALIZATION RESTORATION/MAINTENANCE
- ES&H (AVOIDS ADVERSE LEGAL ACTION & POTENTIAL SHUTDOWN)
- CONTINUE SIS CONSTRUCTION ON DELAYED SCHEDULE
- SUPPORT DEFENSE WASTE TRANSITION TO PERMANENT DISPOSAL
- OPERATE FOUR PRODUCTION REACTORS
- PROVIDE VITAL DETECTION AND ARMS CONTROL ACTIVITIES
- SUPPORT NAVY NUCLEAR FUEL REQUIREMENTS

STRATEGIC DEFENSE INITIATIVE

Mr. FOLEY. What does the budget include? It includes support for the nuclear stockpile memorandum, and support for General Abrahamson's milestones for the nuclear-directed energy weapons. There is one thing that I need to point out on SDI. We front load the defense programs portion, the nuclear side of the SDI effort. Even if the SDI program didn't exist, you would still have to do this research. You would have to do this to find out what——

Senator JOHNSTON. What research?

Mr. FOLEY. The nuclear-directed energy research. In other words, the portion that we do——

Senator JOHNSTON. Including x ray lasers?

Mr. FOLEY. Yes; x ray lasers are one concept. There are several efforts underway. For example, what could the Soviets do to you if they had them?

Senator JOHNSTON. The nuclear kinetic energy.

General ABRAHAMSON. I will point those out in my presentation.

Mr. FOLEY. General Abrahamson is going to cover it. What I am saying is that nuclear-directed energy research is the first step. It is part and parcel to the Strategic Defense Initiative, but it is also fundamental to the basic research that we do for developing nuclear weapons. You need to know what the enemy can do to you if they had this capability. So even if there were no SDI programs, you would still have to do this kind of research.

Before General Abrahamson can really move along in many areas of SDI, he needs to know what the outcome of this research is. SDI is dependent on research and development.

By the early 1990's, we expect to have a feel for the NDEW threat and whether or not you would want to make a judgment on deployment and which technology you would choose. But it is R&D. Some of it isn't going to work and some of it is. You have to define finite milestones so you will have this within the next 6 months and this year you will have another product. It depends on the funding levels provided by the Congress.

The funding cannot go up and down like a yo-yo and still keep a smoothly flowing R&D program though.

FACILITIES REVITALIZATION, RESTORATION, AND MAINTENANCE

The long-range revitalization, restoration, and maintenance bothers me more than anything else in the budget now, because I am responsible for the care and feeding of the entire complex. It is an old complex without much redundancy. You will see television programs that tell horror stories. There are articles in the newspapers about bomb builders doing all these terrible things. You have to take some of this with a grain of salt, but there is some truth in it. The truth is we ought to replace these facilities. We ought to close down the majority of them, clean them up, and get rid of them, and build new facilities with state-of-the-art technology. The complex would probably be a little smaller, but more modern and up to date. We should get rid of these old facilities.

Senator JOHNSTON. And where do we put these new facilities?

Mr. FOLEY. You pick the location. I am not going to sit here and get into the geographics of this thing. [Laughter.]

That's a problem of great peril. All the staffers sitting behind you just perked right up when you asked "where." [Laughter.]

Senator JOHNSTON. And what should we close?

Mr. FOLEY. Well, given the options, you ought to close Hanford and the N Reactor. You ought to close the Savannah River complex, but not until you have replacements for the facilities there.

NEW PRODUCTION REACTOR

Senator JOHNSTON. There is nothing in the President's budget for a new production reactor, is there?

Mr. FOLEY. Yes, sir; there is money in the House and in the Senate budget. As I understand it, there is $20 million for a new production reactor in the proposed authorization bill, but it isn't in the President's budget.

When we started with that budget, we had a game plan that said everything would work all right through the turn of the century. Well, it is not turning out that way. We intend to restart the N Reactor in July, but startup may be blocked.

Savannah River is operating at half throttle, 50 percent of full power.

Senator JOHNSTON. Well, why isn't there anything in the President's budget to replace the production capacity of N Reactor or Savannah River?

Mr. FOLEY. Well, there ought to be. I'll just make that statement. The budget should be revised and $20 to $30 million should be in it for a new production reactor. Much of what has taken place at Savannah River has been subsequent to the time we put the budget together. We need to move forward on a new production reactor.

My personal judgment is that the fiscal year 1989 budget cycle is too late to request a new production reactor. We ought to do it in the fiscal year 1988 process. You don't have to pick the location at this point in time. What you need to do is start the planning for the technology and go through the orderly process——

Senator JOHNSTON. Well, now we have heard testimony on the N Reactor, and while there was an indication, if I recall it correctly, that it wasn't perfect, and it was finite in its lifetime, that ~~there~~ there was no need to do anything for the next few years in terms of a new reactor.

Mr. FOLEY. When are you going to do it? That is the point I am trying to make.

Senator JOHNSTON. Well, that is an executive branch decision to a large extent. You are the one's running the facilities.

Mr. FOLEY. Yes, sir.

Senator JOHNSTON. So we ought to have a budget request from the executive branch—the President and DOE.

Mr. FOLEY. You ought to have a budget request. I agree with that.

Senator JOHNSTON. Because we here in the Congress will have to cut all these other programs to make everything fit.

IMPACT OF FUNDING NEW PRODUCTION REACTOR

Mr. FOLEY. Well, I can get down to the point. I am going to tell you that we have looked across the entire complex, and I am concerned with being able to run this complex with the dollar levels in the President's budget. When we start talking about $500 to $600 million away from it, I don't think you can do that. I will use the analogy that we have a *Challenger* sitting out there on the launch pad. We have this defense complex sitting out there, and you all are telling me to launch, and I am saying, I think that the risk to national security and the margin of safety is sufficient that I am unwilling to do that. We cannot squeeze it or compress it any more. We have to go vertical or shut things down and lay people off. I will give you some examples.

The impact threat is so traumatic that I come back and say you cannot do that. You just cannot close that reactor down. We are talking $500 to $600 million. You may want to take that out of the Department of Defense or get OMB to do it, but don't pass the buck to the Department of Energy and tell us to negotiate with the Department of Defense to see who is going to take a $500 million cut. Make a decision here with respect to where those moneys ought to go. In my judgment, you cannot compress any more. You are going to have to shut things down and you are going to have to lay people off if you are going to keep any revitalization ongong. A cut of this magnitude will give you, by definition, a smaller complex.

SPECIAL ISOTOPE SEPARATION

The other issue is investment in the future. You cannot give up things like special isotope separation [SIS] in Idaho. This is the future. It is coming down the line.

Independent of reactors, SIS is a hip pocket asset that will allow us to clean up the stockpile. We may be able to give ourselves [deleted] more of material, and we need to do this. Then we need to get on with a new production reactor to guarantee a source of tritium.

So we are absolutely supportive of a transition to permanent disposal. Our fiscal year 1988 budget includes funds to operate four production reactors.

NUCLEAR WASTE DISPOSAL AT WIPP

Senator JOHNSTON. Now let me ask you about supporting defense waste transition to permanent disposal.

Mr. FOLEY. Yes, sir; right there.

Senator JOHNSTON. Why did the executive make an agreement with the state of New Mexico to have the WIPP facility store only transuranic waste and not high-level waste?

Mr. FOLEY. The authorization act specified that the WIPP facility be utilized only for storage of transuranic waste.

Senator JOHNSTON. Annual authorization?

Mr. FOLEY. Yes, sir; it is totally separated from the civilian high-level waste.

Senator JOHNSTON. And there is ongoing R&D on high-level waste out in New Mexico?

Mr. FOLEY. Yes, sir; to some degree. Because we have the facility there and we can do it, we are accelerating testing now which would take us years someplace else. But this is not with the intention of putting it there because we are committed to the state of New Mexico that this is not going to be a high-level waste depository.

Senator JOHNSTON. Is there any reason why it cannot be?

Mr. FOLEY. Technically? I will let you know when we get through with the experiments on high-level waste. I cannot tell you that right now.

Senator JOHNSTON. Any apparent reason?

Mr. FOLEY. You are putting me on a spot that I would rather not be on, because I have a commitment with the state of New Mexico that says the Department of Energy has no intention of putting high-level waste in WIPP or in making WIPP a waste repository. It is a very sensitive issue.

Senator JOHNSTON. Oh, I understand that. But you are not the only one that is going to have to make this decision.

Mr. FOLEY. No, sir. Right now I don't know of anything in there.

Senator JOHNSTON. I mean, it is big enough. It is geologically——

Mr. FOLEY. There are legal requirements. But we are talking technical.

Senator JOHNSTON. Yes.

Mr. FOLEY. On the technical side, I don't know of anything right now that would preclude it. For example, going down underneath where we have the transuranic waste, there are some areas down there that could be mined and used for high-level waste. The answer is, technically, at the moment, we think that it is feasible.

PERMANENT WASTE DISPOSALS

Senator JOHNSTON. All right.

Well, what do you have in mind for permanent disposal then?

Mr. FOLEY. Whenever the Congress decides where a permanent disposal site is going to be, then the defense high-level waste will join the civilian high-level waste in that final repository. In the meantime, we are going through with the defense waste part of our plan. We haven't fully laid out a plan on how we are going to handle the defense waste, but it is on schedule. We are currently vitrifying the material at Savannah River and we plan to do the same thing at Hanford. We will continue to make these large glass logs and hang onto these until a decision is made on a final repository. Then we can put them in.

So, we are moving along just fine.

Senator JOHNSTON. You have still got a lot of old liquid waste at Hanford, don't you?

Mr. FOLEY. Yes, sir; we have. We are gradually improving our posture there. We will have to put some new tanks in Hanford. That drags on and on and longer. You will need more tanks in the meantime. We want to get on with the vitrification plant there as soon as we finish the one down at Savannah River. It looks pretty good so far.

There is a small wedge in the fiscal year 1988 budget for funding the vitrification plant at Hanford.

DETECTION AND ARMS CONTROL ACTIVITIES

We are requesting about $100 million a year on verification, arms control activities, and technology. There are the kinds of things that are being talked about over in Moscow now. For example, on verification, what could you do from space? What could you do in other ways out there? Or what hardware could you hang on satellites for the future? We are putting money into new seismic technology. We do ongoing work on these activities all the time. We also provide Admiral McKee's nuclear fuel requirements.

FUNDING OVERVIEW

Mr. FOLEY. This is the appropriation that we had in fiscal year 1986, and we walk across to the fiscal year 1987 appropriation and then to our fiscal year 1988 request. The fiscal year 1987 request represents about 3 percent real growth. The balance of the increase covers inflation. The fiscal year 1989 request includes about the same for inflation, so the result is a small amount for growth over fiscal year 1988.

DEFENSE PROGRAMS

FY 1988/1989 CONGRESSIONAL REQUEST

[DOLLARS IN MILLIONS]

	FY 86 APPROP	FY 87 APPROP	FY 88 REQUEST	FY 89 REQUEST
WEAPONS ACTIVITIES	$4,177	$4,181	$4,535	$4,606
NUCLEAR MATERIALS PRODUCTION	1,768	1,858	1,882	2,220
DEFENSE WASTE & TRANS. MGMT.	618	672	811	771
SECURITY AFFAIRS	186	194	210	255
DEFENSE PROGRAMS	$6,749	$6,905	$7,438	$7,852
			+7.7%	+5.6%

Senator JOHNSTON. What are the principal reasons for the increase?

Mr. FOLEY. We will show you these right now.

SUMMARY OF FISCAL YEAR 1988 INCREASES

I got advanced information on yesterday's testimony, so I have a feel for what you might be asking today.

DEFENSE PROGRAMS

SUMMARY OF FY 1988 INCREASES

FY 1987 CONGRESSIONAL APPROPRIATION		$6906
• ESCALATION (OPERATING, EQUIP, GPP)		+243
• CONSTRUCTION		
—NEW LINE ITEM PROJECTS		+136
—ALL OTHER CONSTRUCTION		-1
• SDI OPERATING AND EQUIPMENT		+167
• TRANSITION DEFENSE WASTE TO PERMANENT DISPOSAL		+83
• FULL ENRICHMENT FOR NAVAL REACTORS		+16
• PROGRAM REDUCTIONS		-112
—INERTIAL FUSION	-38	
—CORE PROGRAM TESTING	-22	
—NUCLEAR MATERIALS PRODUCTION	-52	
FY 1988 CONGRESSIONAL REQUEST		$7438

This is the fiscal year 1987 appropriation and this is how we got down to the fiscal year 1988 request. Escalation is a large portion, $243 million.

Senator Johnston. What does escalation mean? I know it means increase, but——

Mr. Foley. We have to adjust our budget requirements almost 4 percent a year for inflation. Otherwise, we would have to cut current services.

Senator Johnston. That is inflation.

Mr. Foley. Right; that is all it is.

In the area of construction, new line item projects total $136 million.

Senator Johnston. Where are those?

Mr. Foley. There's a variety of them spread across the various program areas. And it is about——

Senator Johnston. A lot of safety, health, and environmental cleanup?

Mr. Foley. Yes; there's about five projects in the environmental, safety, and health area. There's also about $60 million in the aggregate for revitalization and orderly replacement of things, and to make things that have been pushed off a little more vigorous. These range from general maintenance to the SCRAM II construction. Another one is the laboratory facilities at Los Alamos. SDI operating and equipment is also a part of the increase in fiscal year 1988. These are the big items that you see on this chart.

Senator Johnston. What is the operating and equipment request for SDI?

Mr. Foley. SDI operating and equipment. Well, let me think.

Senator Johnston. Why don't you explain that?

Mr. Foley. A small increase is figured for defense waste. This is due to the construction project that is being completed and moving into an operational phase at Savannah River. We are moving along with that one in an orderly fashion.

Senator Johnston. The vitrification facility?

Mr. Foley. Yes, sir; it is turning into an operational facility now.

FISCAL YEAR PROGRAM REDUCTIONS

Now, how do we get some of these increases? We took $112 million away. We took $38 million out of inertial fusion because we wanted to pump up SDI [idicating]. We also had to take some out of the Core Program within the complex and some out of our nuclear materials production. There has been a fence around inertial fusion for a variety of reasons. We feel that you can't keep both the inertial fusion and SDI effort as viable resource programs when you are cutting SDI. That was the President's No. 1 priority. If you are cutting SDI and cutting some of the Core Program, inertial fusion has got to take its cuts too.

Mr. Foley. This is the line item we are worried about more than anything else; this and materials production. The weapons production complex is responsible for producing the weapons, and I think it is in fair shape. Producing nuclear materials is worrisome due to the fact that the N Reactor at Hanford, and the Savannah River reactors, are getting old and are breaking down. They are getting worn out and we have got to replace them. It is as simple as that. And that, to me, is the No. 1 priority we have.

CHALLENGES AND PROBLEMS

Mr. Foley. Aging facilities and meeting the nuclear weapons stockpile requirements head our list of challenges and problems. I just cannot get away from this issue of aging facilities and trying to replace them.

DEFENSE PROGRAMS—CHALLENGES/PROBLEMS

- AGING FACILITIES VS. NUCLEAR WEAPONS STOCKPILE REQUIREMENTS (E.G., NEW PRODUCTION REACTOR)
- WEAPONS TESTING
- CONTINUED PACE OF SDI SUPPORT—OVERLAP WITH CORE AND INERTIAL FUSION PROGRAMS
- INCREASE IN ES&H FUNDING
- FISCAL CONSTRAINTS—WILL REQUIRE VERTICAL CUTS

As I say, the press and all the flack that we take on these facilities; this will not go away. I want to replace them. Close them up, get rid of them, go state-of-the-art and replace them with a new technology. We are doing that now in industry in order to compete with the Japanese. I don't see why we aren't doing it here on our national security side too.

You can't continue to fund the program at the same level year after year and have it go state-of-the-art because things gradually deteriorate. The amount of material that we are producing, for example, year after year is coming down for the same amount of money and the same effort. It is no different than your automobile. You don't get the same mileage out of the thing when it is 10 years old as you did when it was 1 year old. We are doing the same sort of thing here.

WEAPONS TESTING

We have got to continue with weapons testing. The House is now debating whether or not to hang restrictions on it, to limit testing to 1 kt. I must tell you that there are some very flakey initiatives that are being proposed around Washington right now in terms of nuclear testing. It makes no sense to me in anyway at all. As long as you have weapons, you need to test. This is very simple logic. You need to test at 150 kt if you want [deleted] to protect our stockpile. If we can't test up in that range, then you are not going to be able to adequately protect and invigorate your stockpile.

Senator JOHNSTON. And you need to test for SDI [deleted].

Mr. FOLEY. Yes, sir.

Senator JOHNSTON. What do you mean?

Mr. FOLEY. I will let General Abrahamson cover that in more detail.

General ABRAHAMSON. I will cover that in more detail in my presentation, Mr. Chairman.

Mr. FOLEY. But, specifically——

Dr. BARKER. [Deleted.]

Mr. FOLEY. That is right; absolutely right. It also doesn't go together. But those are just two different examples of why we need to test [deleted].

Looking at the weapons coming on down the line now, [deleted] we believe that we would have to test at 150 kt, at a minimum. We are not sure that we are going to be able to meet our requirements by being able to go at 150 kt, but we certainly cannot go any lower than that level. I know that.

ENVIRONMENT, SAFETY, AND HEALTH FUNDING

We are committed to doing things properly, cleaning up some of the environmental insults. We are doing this, and I will show you how that level is increasing. ES&H funding has been increasing at 10 percent a year. As the budget stays fairly flat, this line then goes up 10 percent a year. It is coming out of the nuclear materials and weapons programs. This is the bottom line. We cannot squeeze any more.

BUDGET HISTORY

Here is what's happened starting in fiscal year 1985. Between the President's request and the amount that was appropriated, we lost $228 million. Of course, the Gramm-Rudman impact is included throughout the numbers shown here. But $228 million went out in fiscal year 1985.

In 1986, $727 million was cut from the program and $731 million in fiscal year 1987. You are talking about a $1.7 billion cut over these 3 years from the President's request.

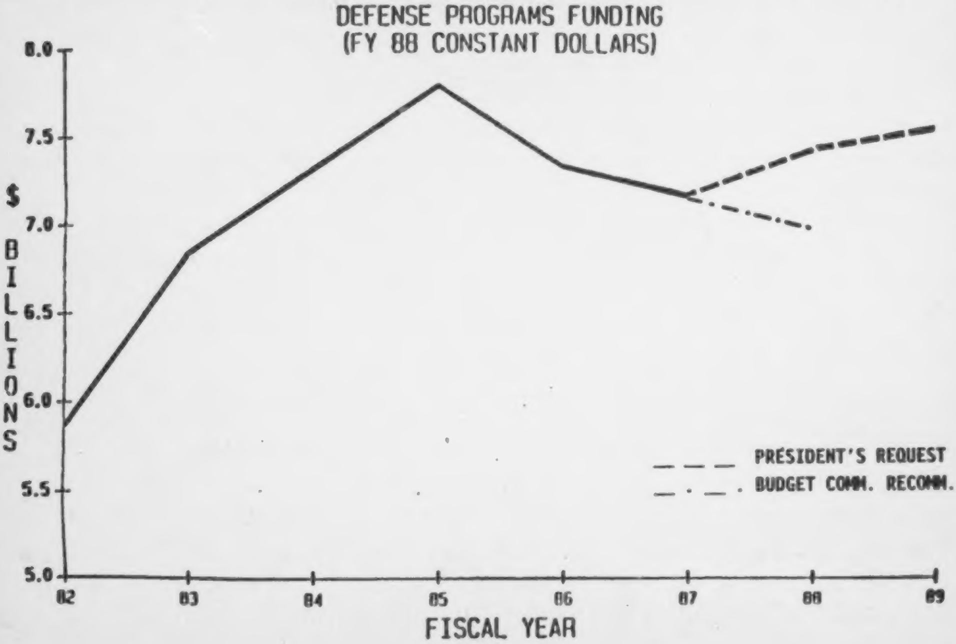
DEFENSE PROGRAMS

BUDGET HISTORY SUMMARY—FY 1985-1988

	FY 1985	FY 1986	FY 1987	FY 1988
PRESIDENT'S REQ.	$7,053	$7,478	$7,636	$7,438
APPROPRIATED	6,825	6,751	6,905	6,905*
DIFFERENCE	$ -228	$ -727	$ -731	$ -533

*BUDGET COMMITTEE RECOMMENDATION BACK TO FY 1987 APPROPRIATED LEVEL.

Now, from what we are told, the House and probably the Senate Budget Committees are working on cutting another $0.5 billion for fiscal year 1987. I am saying that you cannot compress any more. That $1.7 billion cut that we have taken broke the bank. The bucks have stopped. We must go vertical and shut things down and lay people off.



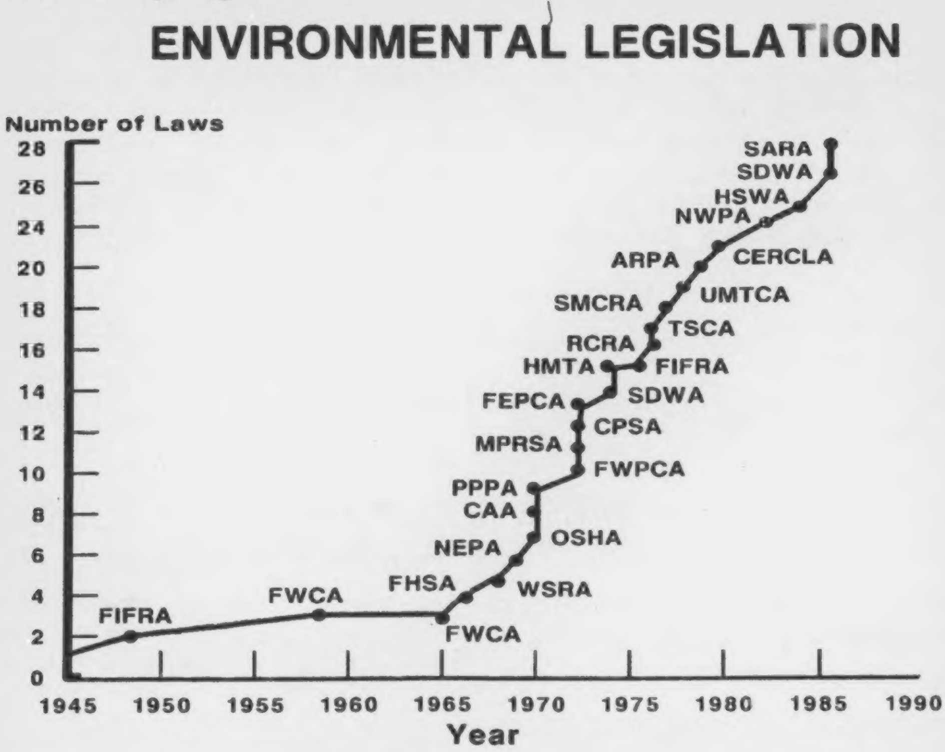
Mr. FOLEY. This is what the budget looked like through 1985 and then here in fiscal year 1987. Now if we got the President's request, that would move us up into this level [indicating]. But it looks like it is going to be down about in here [indicating] from what everybody is saying, a $500 to $600 million cut. So we are moving along in a downward trend.

[Chart deleted.]

WARHEAD DELIVERIES AND WORKLOAD

Mr. Foley. At the same time, the weapons delivery and the workload are staying up or increasing somewhat. The weapons are more complex. They are harder to put together and more man-days of effort go into building them today than in years gone by.

Even though the numbers may stay about the same, and based on past history it will be in the neighborhood of 1,950, or some place about here [indicating] for deliveries. The workload will continue. We can't do anything about it.



ENVIRONMENTAL LEGISLATION

Now we adhere to these [indicating] or we go to jail. I can understand the logic of that fairly easily. I get apprehensive when they say, "Either you do this, or you go to jail." But in the last 20 years we have had a lot more laws to follow and the cost of doing business is going up. How does it go up?

Defense programs have increased funding for ES&H by 31 percent between fiscal years 1985 and 1988. It has gone from $564 million up to $740 million, a 31-percent increase. That doesn't break the bank, but it certainly shows that the trend is upward, and I don't see it going down. It will increase by at least 10 percent a year, and it may get a lot higher than that. It will take billions of dollars in the future to clean up the environment. That is a healthy chunk. There is no question about it.

DEFENSE PROGRAMS FUNDING FY 1988 CONSTANT DOLLARS

[DOLLARS IN MILLIONS]

	FY 1985	FY 1988	DIFFERENCE $	DIFFERENCE %
SAFEGUARDS & SECURITY	$709	$702	-$7	-1%
ENVIRONMENT, SAFETY, AND HEALTH	564	740	176	+31%
PROGRAM BASE	6,523	5,996	-527	-9%
TOTAL	$7,796	$7,438	-$358	-5%

Funding for safeguards and security efforts has stayed about the same. So where does all of this money come from? It comes from our program base, right in here [indicating], which has gone down by $527 million between fiscal year 1985 and fiscal year 1988. Ray Romantowski, our Albuquerque manager, has said that we cannot come down any further. We cannot compress because it is going to close things down.

We laid off about 1,000 people last year in our weapons complex.

LEVEL FUNDING ASSUMPTIONS

We set some assumptions when we brought in the field managers and the laboratory directors in mid-April. We sat down and we said let's take a look at these [indicating] and then we will see where the hard choices are.

DEFENSE PROGRAMS FY 1987 LEVEL FUNDING ASSUMPTIONS

- RESIZE WEAPONS & NUCLEAR MATERIALS PRODUCTION COMPLEX
- RENEGOTIATE WEAPON SYSTEM SCHEDULES
- RESIZE R&D AND TEST COMPLEX
- DEFER REVITALIZATION OF R&D AND TEST COMPLEX
- DELAY TRANSITION TO FULL SUPPORT OF DEFENSE WASTE ACTIVITIES
- VERIFICATION AND CONTROL ACTIVITIES AND SCALE BACK SAFEGUARDS R&D

We will resize the weapons and nuclear materials production complex. We will make it a little bit smaller. We will sit down and renegotiate the weapon systems schedules.

We haven't done it. We haven't sat down with the Department of Defense and tried to work this out yet. We are merely saying that is one of the things we would have to do in order to absorb a $500 to $600 million reduction. We would resize the R&D and the test complex. Well, where is your redundancy in the complex? You have two nuclear reactor complexes and you have two laboratories. Do you shut down one of the laboratories? That gets everybody's attention when you start talking about that, and you really can't do that. It is the same sort of thing with the reactors. Can you shut down one of those complexes and still meet the requirements? Do we defer revitalization of R&D and the test complex? You just can't do that. You have got to revitalize, you have got to look to the future, and you have got to build the SIS. You have to get a new production reactor, and you have to start moving on these things now.

NEW PRODUCTION REACTOR

Senator JOHNSTON. You understand, it is not too late to send up a budget amendment.

Mr. FOLEY. Yes, sir.

Senator JOHNSTON. I mean, you have been talking to us about the importance of this, but that is something that is not even in the budget.

Mr. FOLEY. I understand that, but I am trying to hang on without losing $500 million before I start adding new requirements on top of that.

Senator JOHNSTON. Well, I can tell you how to do that very easily: Get some revenue.

What we have tried to do in this country is reduce taxes, increase defense spending, and bring the budget deficit down all at the same time. It defies the laws of mathematics and logic. It is a kind of self-levitation. You just hope you can pull yourself out of there.

Senator MCCLURE. Or you will start a partisan bylaw.

Senator JOHNSTON. You agree on that?

Senator MCCLURE. No; I don't agree with that. But the growth of the budget has been in entitlements, not in defense.

Mr. FOLEY. Senator McClure, you walked in at just the right time. [Laughter.]

Senator JOHNSTON. Well, I have personally spoken to the President about entitlements, and we really should address that area.

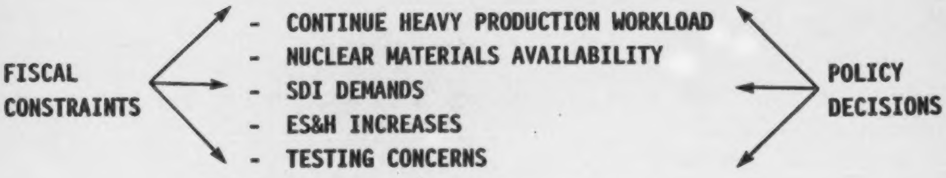
Senator MCCLURE. So have I. That is not a partisan battle. I agree with that. But defense has declined as a proportion of the entire budget from about one-third to a little over 27 percent. Entitlements have grown.

Senator JOHNSTON. Well, we won't get into that. But the Admiral has been talking about the SIS and the N-Reactor. There is no budget request. And I think it is incumbent that the President make that request. I agree, I think we need to look at starting a new production reactor. But it is hard for us to find this kind of money for add-ons in a budget as tight as this when we hear talk about breaking the bank and all of that, including vetoes.

Mr. FOLEY. We cannot even talk about a large chunk of money right now. All we need is a wedge to start working toward a new production reactor. So put $20 to $30 million on it. I would gladly take $30 million out. I will reprogram and get $30 million out of the fiscal year 1988 request. I would happily do it.

What I am attempting to do is keep from taking a cut of $500 to $600 million. I can handle $30 million but I can't handle $500 to $600 million, not without closing down or laying off.

CHALLENGE - MAINTAIN THE NUCLEAR DETERRENT



FISCAL CONSTRAINTS

- CONTINUE HEAVY PRODUCTION WORKLOAD
- NUCLEAR MATERIALS AVAILABILITY
- SDI DEMANDS
- ES&H INCREASES
- TESTING CONCERNS

POLICY DECISIONS

CHALLENGES TO MAINTAINING NUCLEAR DETERRENT

Mr. Foley. What are the challenges facing us? I have got a heavy production workload, nuclear materials requirements, SDI demands, all the things I just talked about, and it isn't all just fiscal constraints. There are policy decisions that must be considered. Testing concerns us most, with the House working on it right now. It is very difficult for us.

DEFENSE PROGRAMS
BUDGET HISTORY SUMMARY
FY 1985–1988

	FY 1985	FY 1986	FY 1987	FY 1988
PRESIDENT'S REQ.	$7,053	$7,478	$7,636	$7,438
APPROPRIATED	6,825	6,751	6,905	6,905*
DIFFERENCE	-$228	-$727	-$731	-$533

*BUDGET COMMITTEE RECOMMENDATION BACK TO FY 1987 APPROPRIATED LEVEL.

Mr. Foley. I have to come back then to a bottom line. You can't take $500 milion out of our request and expect us to accomplish what we want. Let us take the critical path. Keep the production reactors and the supporting structure operating and take $500 to $600 million out of the rest of the complex. OK; that seems logical. We can cut out non-critical areas. So we will close down our SIS; we won't do that at all. We won't have WIPP. We won't have any vitrification, high-level waste plants at Savannah River or at Hanford. We will lay off about 500 people in the laboratories. We will drop about 1,800 people out in the weapons complex. These are the potentials if we go with less. We say, "Well, we can't do that." We are mortgaging the future. This is crazy.

And I agree. We need to continue with SIS and our waste cleanup, and we need to continue with WIPP.

Well, if this is the case, then you move back into your critical path, and the critical path area is your production reactors, your weapons complex. What are you going to do? Are you going to close down one of your laboratories? Are you going to shut down reactors? You can't do that. We are talking about a new production reactor for tritium, sure, but don't get rid of the ones you have until you have a new one coming on line and get on with that right now.

When I look at these alternatives, I say, how in the world can I revitalize and build this thing up a little when I am trying to take $500 million away at the same time? I cannot do it. I just cannot do it.

With regard to the defense programs complex which is sitting on a launch pad for the next year, I am unwilling to push that button, and tell it to go ahead if you are telling me to take away $500 million. I won't do it.

WEAPONS TESTING

Senator JOHNSTON. Admiral, is it true that you need [deleted] to test triggers?

Mr. FOLEY. Yes, sir.

Senator JOHNSTON. And that to go up to the 150 kilotons is for the secondaries. Now, if you could test the trigger—and nobody is really proposing this, but I am just wondering about it—if you could test the trigger and not the secondaries, what do you lose?

Mr. FOLEY. I lose confidence.

Senator JOHNSTON. I mean, the trigger is the most important part, isn't it?

Mr. FOLEY. Well, you can't pick on any one particular thing. If the trigger doesn't work, the secondary is not a consideration. But if the trigger works, and you are working, let's say, on a 300-kt weapon, and you get a 25-kt burst out of it, that doesn't help you a lot. The whole thing comes as a package, for example, if one engine works on the aircraft, I need to know whether the rest of that aircraft works too.

When I put a bomb together, I can show you a stairstep—I don't have it with me; the laboratory directors have it—a stairstep that says at 150 kt I could test about [deleted] of my stockpile. I can test the primary and I can test the secondary at 150 kt.

As you walk down to lower levels, you diminish the amount of the stockpile that you can test. At [deleted], we can test most of the primaries. We can do weapons effects work, but you do not know whether or not the stockpile is going to work at the level for which it was designed.

So the risk increases tremendously.

NEW REACTOR TECHNOLOGY

Senator JOHNSTON. Senator McClure?

Senator MCCLURE. I apologize a little because I am afraid I am going to replow some of the ground that you have already covered. But I hope the question is at least a little different than the way you have covered it already.

I have no question at all that there is the need to replace our production facilities. I have no question at all concerning the need to maintain production facilities until the replacement is available. I agree with you totally on that.

But the Department has indicated that the fiscal year 1989 budget request will include funding to address the issues.

Mr. FOLEY. Yes, sir.

Senator MCCLURE. Does the Department plan to initiate studies to reassess and to reevaluate reactor types and possible sites prior to the fiscal year 1989 budget request?

Mr. FOLEY. Yes, sir; we have ongoing at the present time a request to the National Academy of Sciences—in fact, today we are finalizing the work definition of this particular request—asking them to look at a liquid metal breeder reactor technology and a high temperature gas reactor technology. These seem to be the two in the forefront. We already have plenty of information on the heavy water reactors and light water reactors. So these are the three technologies that we are looking at, but we are not excluding others. These are the three primaries that we are focusing on, so we can move ahead and select one of these technologies for a new production reactor for tritium.

It is just a question of getting on with selecting the technology. We have done lots of studies in the past and we have upgraded our own internally. We have asked an external group to take a peek at it just to make sure that one of the——

Senator MCCLURE. All right. That is the question I was really addressing, is that obviously a great deal of work was done in this field before the NPR was abandoned a few years ago.

Are we reinventing the wheel? Are we going back and replicating all the studies that were done then, or are we simply updating information?

Mr. FOLEY. No; we are simply updating, sir, because we want to be sure. I don't want to see any white elephants sitting out there around the country. There are a few of them already out there. So you want to be sure that the technology that you select is, in fact, the proper one to go forward with at this particular time. We want to get on with it as quickly as we can.

As I say, we have completed our own internal updating of our studies. Under Secretary Salgado has asked the National Academy of Sciences to take a look at these two principal new technologies and give us some information back; not to make a decision. We will make that decision. But give us the technical information that, hopefully, will support and be equivalent to our own information. Then we will make a quick choice and move on.

Senator MCCLURE. Now obviously you would know and you would expect that I have a parochial interest as well as a national interest.

Mr. FOLEY. Yes, sir.

Senator MCCLURE. And I shouldn't try to hide either that fact or the fact that I assume you know it.

As you know, Secretary Hodel had made the announcement that Idaho was the preferred site. Is there a reevaluation of that decision or is there a reevaluation of the basis for that decision?

Mr. FOLEY. The site is not a consideration at this time. We really haven't gotten that far, quite candidly. We are looking at technology.

Now, if you pick a particular technology, one location might be more desirable over another because of support facilities, and so forth. It depends to some degree on the technology. You want to pick the best technology and get on with it. Then that could be a determinant as to the site selection. I am not willing to say at this point where it should go. Let's settle on the technology first.

SALE OF POWER FROM PRODUCTION REACTORS

Senator MCCLURE. In your evaluations and in the information that you have asked of the outside experts to evaluate, have you looked at the sale of power as a part of that evaluation?

Mr. FOLEY. The sale of power is a consideration as far as the evaluation; yes, sir. Now whether you are going to do that as a cost ameliorating measure or you do not want to do it because it is a problem to you, there are pros and cons. We are looking at that, quite candidly, because if it is placed in a standby status, how can you keep that expertise and keep everybody working there if it isn't a power producer as the N Reactor was for many, many years?

The power producer option becomes very attractive because you can keep the reactor either operating or on standby and have a facility that is still viable.

The answer is we are looking at this both as a possible power producer or not as a power producer in the long run.

Senator MCCLURE. Do you have any conclusion in your own mind at this time as to whether that evaluation is positive or negative? Setting aside for a moment the technology, just the issue of whether or not the options to reduce life cycle costs, which is really what we are talking about, isn't it, when we are talking about power production? We are not putting a power unit on in order to meet a power need. We are not putting it on there to prove a technology. We are putting it on there to reduce life cycle costs.

Mr. FOLEY. It reduces life cycle costs. You will also acquire a large headache when you do that.

Senator MCCLURE. Was the sale of power at the N Reactor a large headache?

Mr. FOLEY. Yes.

Senator MCCLURE. In what way?

Mr. FOLEY. It was a plus in that we were able to keep it operating, but it is another thing to worry about that is not fundamental to the mission for which the reactor was designed. A reactor designed to produce plutonium should incorporate the most proven technology, with the least risk, the most reliability, and the least problems, is low pressure, low temperature. Why do I want to get myself in the marketing business with selling electricity if my real concern is producing plutonium? This is just another headache I don't need. All right. That is one consideration.

The other consideration is that you can keep that a viable complex, as the N Reactor demonstrated, during the whole time that you are not producing nuclear materials, but you have got the whole thing still active enough that you can start producing nuclear materials quite easily.

There are pros and cons on both sides. I am being very candid in giving you these. As a tritium producer, why do I want to be in the electricity business where I have to deal with a lot of people other than those involved in the fundamental role of producers? But there may be sufficient benefit for doing that in terms of keeping the reactor operational. It also reduces the overall life cycle costs.

Senator McClure. A lot of reduction in life cycle costs.

Mr. Foley. Yes, sir.

Senator McClure. Is from that standpoint——

Mr. Foley. Very effective; yes, sir.

NEW REACTOR ENVIRONMENTAL IMPACT STATEMENT

Senator McClure. At the time that the INEL was named as the preferred site, the question of when an EIS should be conducted became an unresolvable issue. Has the Department now found a way to solve that problem?

Mr. Foley. Yes, sir; we will save that one for the record.

Senator McClure. All right.

[The information follows:]

New Production Reactor EIS

It is our understanding that the problems with timing of the environmental impact statement [EIS] for a new production reactor previously expressed by the House Armed Services Committee can be resolved by the Department through appropriate preparatory activities defining a preferred concept and site.

Senator McClure. And I am perplexed. I don't know which comes first, the chicken or the egg. And that is the question we are asking.

Mr. Foley. As you know, sir, my new principal deputy, Troy Wade, is coming here from Idaho, and I am sure that he will be perfectly willing to take that subject on. [Laughter.]

NEW REACTOR TECHNOLOGY

Senator McClure. He will die a thousand deaths already.

At this time is there any conclusive evidence to show that one particular technology could be built more rapidly than another, a time differential?

Mr. Foley. I would really like to hold off on this discussion until I get the National Academy of Sciences information on it. That is one of the considerations.

Senator McClure. You have done your own studies internally though. Would you rather not be exposed to being different than the National Academy?

Mr. Foley. At this point, yes, sir.

Senator McClure. Well, I understand that. I would like to test your ideas against theirs. That is the reason I asked the question.

Mr. Foley. Why don't we test them together when I get their results on it. And then we could take one or the other and see what the differences are rather than coming out with a statement beforehand. If we are going to get an objective evaluation to make our decision, I would prefer to get their input first. What have we got to lose?

Senator McClure. Do you think what you would say today would prejudice their ability to be objective?

Mr. Foley. Well, I would rather be consistent in what I say and not have to backtrack 180 degrees from something we might know——

Senator McClure. I understand that. That is why I was giving that.

When will the National Research Council report be available?

Mr. Foley. Not early enough is an answer I will give you. I would like to see it much quicker. I would like to have it today, for example. I am afraid it is going to take us into the early autumn before we get that. And we have asked them to do it as quickly as they possibly can. But that whole process is a fairly laborious one. It takes a while.

Senator McClure. Thank you very much.

As you would note, I am very supportive in your general programs and I want to be as helpful as possible to be. I was disappointed when the decision was made not to build the NPR. I think, in retrospect, that proves to have been a less than totally wise decision. And it may have been budget driven rather than policy driven.

Mr. Foley. Sir, I am sure that there were justifiable reasons at that time. When I came in, I inherited a program that said an orderly upgrade, a replacement through the turn of the century at both Savannah River and N Reactor was in process. The facilities looked pretty good, but subsequent events have shown that a decision to go forward with an NPR a couple of years ago would have been a good one. And in my judgment, that time is certainly here now. It is time to do it right now based on everything I see.

I get very uneasy about this entire complex and the fragility of it. And we need to replace it, close all these things, clean them up, do our environmental upgrades, and probably have a smaller but more modern complex that is safe and environmentally acceptable, and we need to get on with it and make that commitment right now. We can't wait any longer.

Senator McClure. Thank you.

Senator Johnston. Thank you very much, Admiral.

Mr. Foley. Yes, sir.

Strategic Defense Initiative

STATEMENT OF LT. GEN. JAMES A. ABRAHAMSON, DIRECTOR, STRATEGIC DEFENSE INITIATIVE ORGANIZATION

ACCOMPANIED BY:

LT. COL. RICH DAVIS, ASSISTANT DIRECTOR OF DIRECTED ENERGY, SDI

PREPARED STATEMENT

Senator JOHNSTON. General Abrahamson?

General ABRAHAMSON. I will submit this statement but not read anything from it at all, sir. It is a similar statement to what we presented to the House as we were supporting the Department of Energy in our testimony there.

[The statement follows:]

STATEMENT OF LT. GEN. JAMES A. ABRAHAMSON

Mr. Chairman it is a pleasure to appear before the Committee to discuss with you the Strategic Defense Initiative (SDI) and the importance of the Department of Energy's (DOE) role in the SDI research program. As the Administration requests funding for the fourth and fifth years of the Strategic Defense Initiative, it is useful to look ahead at the challenges that remain for this very important Initiative. This month marks the fourth anniversary of President Reagan's decision to establish the Strategic Defense Initiative. I am pleased to report that in research and technology development, many exciting developments have taken place over these four years. As a result of their active interest and participation in the SDI Program, our nation's scientific, industrial, and academic communities have fostered some of the finest, most sophisticated technological advances of this decade.

However, while technological advances have filled us with hope and spirit of what our research might produce, we cannot ignore the fact that some aspects of this world have not changed. As was the case four years ago, and is even more apparent today, the Soviet Union is engaging in a determined, steady buildup of strategic nuclear weaponry improving their capabilities across a wide spectrum of strategic warfare. Moreover, Soviet strategic defenses are extensive and growing. The Soviet Union has the only established anti-ballistic missile system, the only anti-satellite system, the most comprehensive air defense system and the most intensive research and development effort in the application of new technologies to ballistic missile defense in the world today -- ground- and space-based lasers, particle beams and microwave weapons, interceptors, heavy lift space transportation vehicles, and tracking and surveillance systems. The President has charged the Department of Defense with defining real options for using defense to counter the Soviet progress in improving strategic offensive and defensive forces. SDI could provide a hedge against the real potential for Soviet efforts to exploit emerging ballistic missile defense technologies and possible breakout from the ABM Treaty.

The essence of the SDI Program, as directed by the President, is to provide effective defense options for a future decision to develop and deploy ballistic missile defenses. Since the ballistic missile threat is the most capable of accomplishing a disarming first strike, we are conducting research to find ways to defend against this threat, thereby providing a better basis for deterring aggression, strengthening strategic stability, and increasing the security of the United States and our allies. I must emphasize that the SDI is not a bargaining chip to be given up for arms reduction but instead is a catalyst that encourages meaningful arms reduction, yet remains as insurance against Soviet cheating or breakout.

Initially, the SDI Organization (SDIO) based its plan to fulfill our goals on an independent scientific assessment, the Fletcher Commission Study. We designed a vigorous, goal-oriented program designed to ensure that the researchers have a defined target and clear knowledge of the desired capabilities.

To meet our goal, we have defined a basic investment strategy with three major thrusts. First, we are bringing the most mature technologies to the point that if the decision were made to proceed, the job of developing and deploying the individual system concepts would be largely one of engineering. Second, we are pursuing the development of emerging technologies that have the potential for major improvements in defense effectiveness. And third, we are ensuring that an investment be made in innovative ideas that hold the promise of great success, although they present a higher technical risk. These innovations could yield a high payoff in achieving a thoroughly reliable defense.

Our intent has been to demonstrate technical feasibility of effective strategic defense and to provide a range of effective defense options to the President, the Congress, and the American people. We have made great progress in this regard. But while the Congress has increased SDI funding every year, the differences between what the Administration has requested to conduct a balanced research program and what the Congress has appropriated, are so large that if this trend continues, it will have a very substantial detrimental impact on the Program.

Large budget reductions from the FY 1985 and FY 1986 requested levels caused a reduction in the number of promising technologies being pursued in parallel and increased the difficulty of realizing adequate solutions to specific technical issues. Additional sizable reductions made in FY 1987 have placed SDIO in a position where simply scaling back some technologies is no longer viable. Specifically, some portions of the SDI Program have been slowed approximately one to two years. In light of the Soviet threat cited above, we are extremely concerned about this slowdown. To date, despite reductions to the Administration's funding requests, the SDIO is pursuing a balanced program in which both the technology base and technology validation efforts received equal emphasis. However, the SDIO will not be able to maintain this essential balance if the trend of relatively large reductions to the Administration's requests continues.

With regard to balance and our concern about the Soviet threat, let me reiterate the importance of the Department of Energy's role in SDI. As I discussed in last year's testimony, the DOE supports SDI in two basic ways, through reimbursable support to DOE National Laboratories for performing direct SDIO mission oriented work, and through DOE-funded support that falls within its statutory role of nuclear weapons research.

The reasons for the nuclear research have been clearly outlined jointly by Secretary Weinberger and Secretary Herrington and are outlined below.

1. To determine the feasibility and effectiveness of counterdefensive nuclear-driven systems that an adversary may develop for use against future U.S. surveillance and defensive systems.

2. To understand the technical feasibility and impact that such concepts might have on our deterrent forces if utilized in Soviet defensive systems.

3. To explore nuclear directed energy options as ballistic missile defense possibilities if needed.

One should recognize that SDI is a program that is fully compliant with the various treaties (including the 1972 ABM Treaty entered into by the United States and the Soviet Union). However, the President has directed that the Program emphasize non-nuclear defensive systems. Clearly, the Soviets are under no such constraint about pursuing such research, or using nuclear weapons or nuclear directed energy weapons (NDEWs) in their defense systems. The current ABM system deployed around Moscow uses nuclear warheads. The Soviets have done research on NDEW -- some earlier than our own. Because of this, a particularly important aspect of our research on NDEW is to understand its feasibility in countering United States retaliatory forces, and in a counterdefensive mode as it might be used by the Soviets to destroy space-based elements of United States surveillance systems and a future United States strategic defense system.

Also, NDEWS may be useful as part of a future ballistic missile defense system. A NDEW would use a nuclear explosion to power narrow, intense beams of energy in selected direction to destroy attacking missiles or reentry vehicles at distances hundreds or thousands of miles in space. In contrast to the approaches of some early ABM system designs, which used traditional nuclear weapons, there would be far fewer explosions and they would be in space, so that we would expect no damage to people or structures on the ground. A NDEW might be ground-based and popped up into space as needed rather than based in space.

Last year, the President transmitted a message to Congress proposing the transfer of $62 million from the Department of Defense to the Department of Energy in Fiscal Year 1986 to accelerate research on nuclear directed energy concepts. We want to thank you for your support of this transfer, and request that you complete this year's portions of this action promptly.

We submitted our request for the $62 million transfer because our knowledge and understanding of nuclear directed energy technology has advanced significantly and this knowledge has increased the importance of the nuclear directed energy research program to the national Strategic Defense Initiative Program. Our new understanding is the result of the significant progress made in the nuclear directed energy technology and the results of SDI Architecture Studies which showed the dramatic impact, especially in the threat area, that an adversary's nuclear directed energy weapon (NDEW) could have on national security. It is vital that the Department of Energy's level of effort on SDI research be increased during Fiscal Year 1988 and beyond so that the feasibility and significance of the technology, particularly the potential threat it poses if developed by the Soviets, can be properly considered in future Strategic Defense Initiative programmatic decisions. It is essential that this technology and its critical milestone schedules be synchronized with the expected maturation of SDI technology developments. Otherwise, programmatic decisions will be based on an inadequate understanding of nuclear directed energy feasibility.

To support DOE's Fiscal Year 1988 requirement in NDEW, and to support critical milestones, DoD agreed to reduce its budget request by $100 million so DOE could increase its request by the same amount. We hope this show of DoD support for the DOE program can be translated into your full support as well.

In summary, the SDI research Program has always contained efforts carried out jointly by the Department of Defense and the Department of Energy to explore the technical feasibility of NDEW. In the past, funding for NDEW has been approximately 10-15 percent of the total SDI budget. DoD and DOE are seeking increased funding for NDEW research, but this will not exceed the usual proportion, since the Administration is also seeking funding to increase the overall SDI research.

The SDI Organization recommends that Congress support the DOE requests to allow the completion of critical feasibility tests in time to impact our decision time frame.

INTRODUCTION OF ASSOCIATES

General ABRAHAMSON. I am privileged, of course, to be able to present our program and this very vital part of it. And I think the most simple way to do that is with a few charts. And I have Colonel Davis who will assist there. And by the way, I haven't introduced to members of this committee my deputy, Dr. Gordon Smith, who is in the corner back there. And I would like for all of you to know him since he is a great assistance to me and I hope he will be assistance to you as well.

SDI PROGRAM OBJECTIVES

The first and most important point, and I won't go through this, is that in all of the committees I have tried to stress that the objectives on the program have not changed at all.

SDI PROGRAM OBJECTIVES

- CONDUCT A COMPREHENSIVE R&D PROGRAM TO DEVELOP KEY TECHNOLOGIES FOR DEFENSE AGAINST BALLISTIC MISSILES
- CONSIDER OPTIONS TO INCREASE THE CONTRIBUTION OF DEFENSES TOWARDS DETERRENCE
- PROVIDE THE BASIS FOR AN INFORMED FULL SCALE ENGINEERING DEVELOPMENT DECISION IN THE EARLY 1990s
- PROTECT OPTION OF A NEAR-TERM DEPLOYMENT OF A LIMITED ABM CAPABILITY AS A POSSIBLE RESPONSE TO SOVIET ABM BREAKOUT
- EMPHASIZE NON-NUCLEAR KILL MECHANISMS
- COORDINATE SDI WITH OTHER DEFENSIVE PROGRAMS AND SUPPORT OTHER STRATEGIC DEFENSE MISSIONS

In terms of the direction for nuclear-directed energy systems under investigation. In one respect, it is separate from SDI, because—and I think the Admiral put it very, very well—that is a new direction. It is a new direction for nuclear physics and certainly for weapon physics. It is a direction that the Soviets have been proceeding with. It is very difficult for us to know how far they are along in that whole process, and whether or not we build an SDI, if indeed the potential of some of these systems are explored by the Soviet Union.

The offensive retaliatory force that we have may well be faced with a Soviet SDI system that has as a basis for it some of the nuclear concepts. Therefore, we must understand what the threat of these nuclear concepts, this third generation of nuclear weapons is, both to our offensive retaliatory forces and certainly for SDI. We need to know what kind of a threat they may represent for a potential SDI system that we may put up, because they do have very, very high potential.

Obviously in the process of doing that, one cannot help but examine how that might be used in an SDI system. But I would like to stress that the President's desires here are very clear, and that is to, if at all possible, to be able to proceed with an SDI system that is nonnuclear in terms of requiring nuclear weapons. That does not mean that we will not examine what those potentials are. I don't believe that the President's policy ever meant that we should just ignore the potential of any technology, but his desire and his preference is that we try to build a nonnuclear system and that is what we are embarked on.

Now the overall effort does show that some of the nuclear-directed energy systems which are, of course, included in the Department of Energy budget as opposed to the SDI budget, do have some unique capabilities.

PROPOSED REDUCTION IN SDI PROGRAM

But I would also like to point out that, in fact, the Department of Energy laboratory system and its people are perhaps some of our most valued resources in this whole nation because of their advanced capability, and that the dramatic cuts that have been offered by the House at this point in the fiscal year 1988 budget would have a very substantial impact on not only the technical aspects of the program, it could only be met by dramatically reducing the number of people in the laboratory. By reducing that, it not only affects the SDI program, it affects this fundamental infrastructure that Admiral Foley talked about.

Now, some of that is offset because we have a very vital program that is not in the Department of Energy budget, but again makes use of Department of Defense funds to carry out programs which are nonnuclear but where the best expertise in the nation again lies in the laboratories; the dramatic cuts that have been forced on us in the last several years as well as the potential if the House level that has come out of the House Armed Services Committee——

Senator JOHNSTON. What was that House level?

General ABRAHAMSON. Sir, it is a little hard to tell exactly, but it is a $3.5 billion level. And some of it is taken out of our budget and put in other places. And I think there was additional action just yesterday and maybe today.

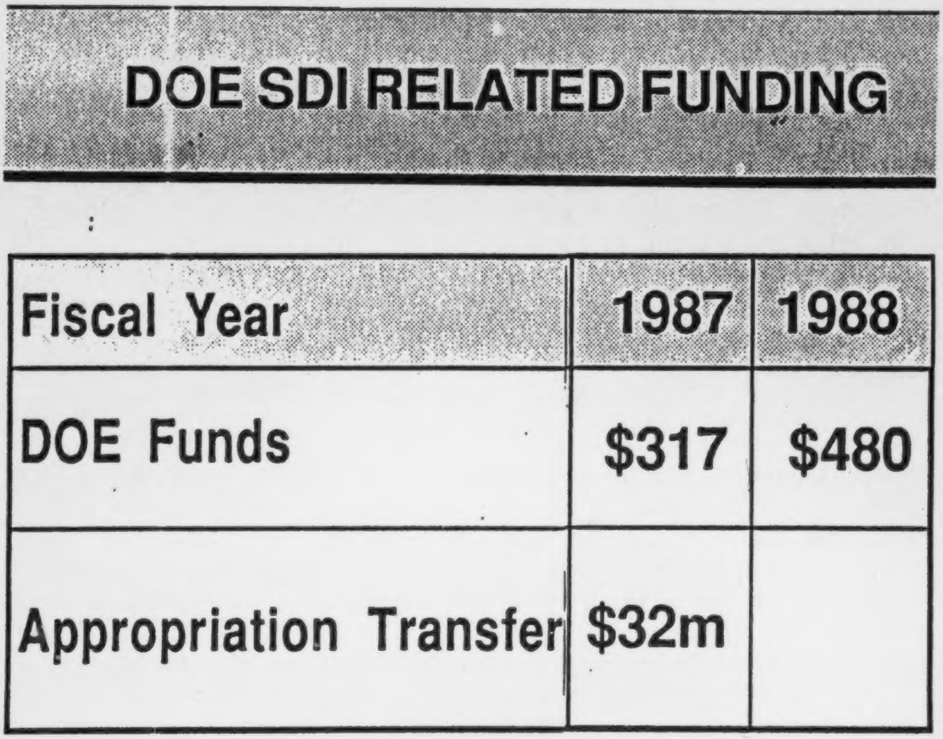
Senator JOHNSTON. But $3.5 billion, including DOE?

General ABRAHAMSON. No, sir; it is not including DOE.

The House action for the Department of Energy is $279 million, as opposed to our $480 million request that we made, and I will show those in just a minute.

Senator JOHNSTON. All right.

General ABRAHAMSON. In general, the SDI-DOE budget has been about 10 percent of the total, in addition there is a substantial amount of reimbursable funding that comes from the Department of Defense, again, to use the very vital people and research capability that are just so rich and so helpful to us primarily in our nonnuclear-directed energy programs. Those are the free electron laser efforts, the neutral particle beam efforts, those kinds of efforts.



DOE SDI RELATED FUNDING

Fiscal Year	1987	1988
DOE Funds	$317	$480
Appropriation Transfer	$32m	

General ABRAHAMSON. Now here is our DOE-SDI funding, and to that $317 million—I'm sorry, I gave you a wrong number here. I was thinking of the appropriation transfer adding to the 1988 budget—that adds to the 1987 budget. And that was where we transferred money from the already appropriated fiscal year 1987 Department of Defense budget. That is a recognition of the vitality and the importance of the nuclear-directed energy activities.

COMPETING TECHNOLOGIES

Here are some of the nuclear-directed energy concepts that are being looked at and do require underground testing, as well as a great deal of theoretical work, some of it which is carried on in laboratories and some with some of the nuclear reactors that are available.

With the cuts that we have had in the past, we have had to cut back on several of these things very dramatically. We are still carrying out as the most important threat to both SDI and to our conventional forces and the ones that we believe the Russians are pursuing—although it is very difficult to get clear evidence of exactly where they are—[deleted].

Senator JOHNSTON. What is the size of the [deleted].

General ABRAHAMSON. I'm sorry.

Senator JOHNSTON. What is the size of the [deleted].

General ABRAHAMSON. Oh, the [deleted]. What comes out, sir, is [deleted]. You use a very, very [deleted]. At this area we are talking about 10,000 pounds of dynamite, equivalent to [deleted].

Now, the testing is to try to see if we can control those, make those even smaller. There is a separate activity which is really saying, can we break it down to the [deleted]. And the principal objective there would be not to see, can you destroy. It would not be a lethality mechanism, but would be a discrimination mechanism to take a group of very closely spaced objects which are made up of light balloons and various kinds of decoys, [deleted].

Senator JOHNSTON. How wide do you perceive the [deleted] as being?

General ABRAHAMSON. Well, that is part of the experiment at this point in time, and I cannot give you a number at this point. We really have to look at that [deleted]. I think that is possible in the way that you send up the [deleted]. But those are precisely the elements of the experiment.

OK. That is one concept with two applications: discrimination and destruction. And it is fairly straightforward. The theory is well known and it is very hard to tell what the Soviets may be doing in this area. This does not require things that are highly signature dependent.

[Deleted.]

So those [deleted] are the ones that we consider to be the primary activities. Now, we had——

Senator JOHNSTON. You proved [deleted].

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. And the principle, yes. And now you are working on keeping the [deleted] or has that been solved as well?

General ABRAHAMSON. Well, this is kind of a mixed bag always. It is correct. We have examined several types [deleted].

Colonel DAVIS. [Deleted.]

General ABRAHAMSON. [Deleted.] All right.

We are expanding our base of knowledge there.

[Deleted.]

[Laughter.]

Mr. FOLEY. And would be.

General ABRAHAMSON. [Deleted.]

Senator JOHNSTON. [Deleted.]

General ABRAHAMSON. [Deleted.] So that was a very, very important step.

[Deleted.]

Senator JOHNSTON. Well, they don't have to be around very long.

General ABRAHAMSON. That's correct, they don't.

[Deleted.]

The other techniques we have had to cut back dramatically. That doesn't mean that they aren't vital and of interest to us, but we have had to cut back such things [deleted].

[Deleted.]

Senator JOHNSTON. That is an x ray laser as well.

General ABRAHAMSON. No, sir; that is not an x ray laser.

Colonel DAVIS. It is a visible laser.

General ABRAHAMSON. It is a visible laser.

X ray lasers cannot penetrate the atmosphere very far. [Deleted.]

FREE ELECTRON LASER

Senator JOHNSTON. There is nothing about the free electron lasers that has discouraged you as a candidate for [deleted] for instance, at the right frequencies, is there?

General ABRAHAMSON. No, sir. [Deleted.]

The free electron laser is a very fine concept. We have now gotten down to frequencies that are in a visible range and I think that is really exciting. In fact, that is one of the developments even since the drafting of the American Physical Society report that was talked about and just released, and talked about the difficulty of getting down into the right areas for the free electron laser. It is difficult. There is no question about it.

But since that report was drafted, and that group of people have been out, we have now done exactly that point. We have done it at very low power. We still have to get to high power. So there are difficulties.

CENTAURUS

One of the other concepts in Centaurus, and that is using a nuclear reactor and going directly from that nuclear reactor to a laser, and getting lasing directly from the nuclear reactor. We have had a very, very low funded program. We used the threat reactor at Idaho, at the INEL, and they did some very exciting work. And I think it was about 1½ years ago that I visited those people, and they were, I think, making a great deal of theoretical progress.

Senator JOHNSTON. What do you think your power requirements are?

General ABRAHAMSON. In terms of the size of the nuclear reactor itself?

Senator JOHNSTON. In megawatts.

General ABRAHAMSON. I can't——

Colonel DAVIS. The laser reactor itself is on the order of [deleted] So the reactor would correspondingly be at least [deleted] more thermal power. Operated over a very short time period. So it is not the type of reactor you talked about before, for commercial power generation.

Senator JOHNSTON. What kind of weight parameters are we talking about?

General ABRAHAMSON. You mean to get into orbit, sir?

Senator JOHNSTON. Yes; in orbit.

General ABRAHAMSON. For that particular time. We haven't designed that. And I am not sure that we even have a credible estimate because of the different kinds of reactor.

Senator JOHNSTON. Do you have any estimate at this time?

General ABRAHAMSON. We are way down in the theoretical studies at this point.

Senator JOHNSTON. Any estimate of the length of time for power up on that?

General ABRAHAMSON. To be able to react very, very quickly. I don't.

Senator JOHNSTON. But do you——

General ABRAHAMSON. But if you would like that for the record, then I would like to come back and answer these the best I can. But I don't have that answer.

Senator JOHNSTON. All right.

[The information follows:]

DIRECTED ENERGY CONCEPTS

There are many approaches under investigation, but from a mission standpoint we require all directed energy concepts to have the capability to go from a standby status to full power in times scales of tens of seconds. We see no reason why this concept cannot meet this requirement.

General ABRAHAMSON. What we have been doing so far is that we have indeed achieved gain measurements. We did that at Sandia as part of the Falcon effort.

Senator JOHNSTON. You are talking about Centaurus now?

General ABRAHAMSON. No; for this Centaurus concept.

Colonel DAVIS. There are two programs. One is the Centaurus program, which is being pursued in Idaho. The other is the Falcon Program, which is using pulsed reactors that Sandia Laboratories is pursuing for us.

Senator JOHNSTON. Do you know that there is electricity in the lasing?

Colonel DAVIS. No, sir.

General ABRAHAMSON. Go ahead.

Colonel DAVIS. There is direct conversion from the fission fragments into the gas. So there is no electricity generation at all.

Senator JOHNSTON. Thank you.

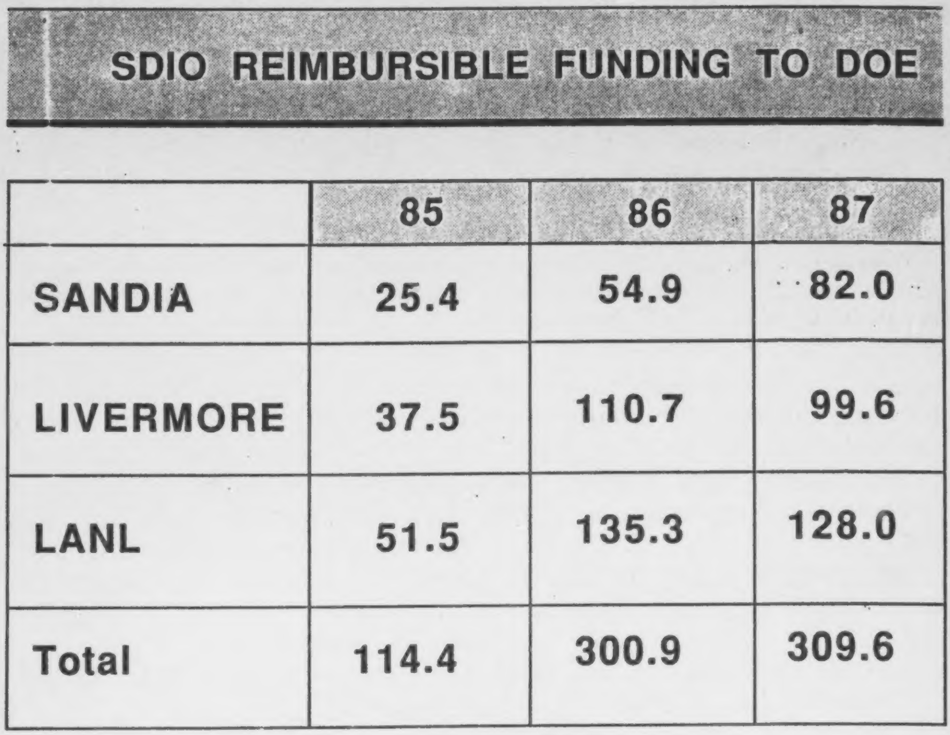
General ABRAHAMSON. But that has been cut back just dramatically. The only things that we are really able to proceed with at all are those two. Now we have been able to carry forward the microwave program, and that is a program——

[Chart deleted.]

SDI-RELATED NUCLEAR WEAPONS TESTS

General ABRAHAMSON. You can see in terms of the number of nuclear tests in red are the dedicated SDI tests that we have had. And those dedicated SDI tests fall primarily in the area of [deleted] those kinds of underground tests.

On the very top in the cross-hatched area are weapons effects tests. Those are Defense Nuclear Agency tests that are conducted to look at a variety of weapons effects tests. [Deleted.]



SDIO REIMBURSIBLE FUNDING TO DOE

	85	86	87
SANDIA	25.4	54.9	82.0
LIVERMORE	37.5	110.7	99.6
LANL	51.5	135.3	128.0
Total	114.4	300.9	309.6

DOE REIMBURSABLE SDI WORK

This is our reimbursable funding to all of the laboratories. And as you can see, it is a very appreciable amount proposed. And that would be proposed to have built up. I don't know, of course, what the fiscal year 1988 outcome will be and what those cuts will have to be. But the amount of proposed cuts in the House are 40 percent. There is no way to deal with those kinds of cuts without having to cut all aspects of the program, including some of this reimbursable funding.

That doesn't mean that these teams are not important to us nor that the outcome of what they are about. It just means that you can't absorb 40-percent cuts without examining all pieces of the program.

Senator JOHNSTON. You mean 40 percent cut off the——

General ABRAHAMSON. Of the total DOD budget. And that DOD budget has included a very substantial portion that goes back as reimbursable funding into the Department of Energy.

For example, at Los Alamos, the high powered free electron laser, that is the RF version of the free electron laser. And they have made great progress in that area. It has been just dramatic.

NEUTRAL PARTICLE BEAM

In addition to that, the neutral particle beam concept, they have been very supportive of an experiment that could be conducted in space, as well as conducting ground experiments with the neutral particle beam.

Senator JOHNSTON. That is the chemical laser?

General ABRAHAMSON. No, sir; that is the neutral particle beam concept. What that is is we have ground versions of the neutral particle beam operating at the White Horse facility at Los Alamos now. That ground version is showing us that we understand the physics and, in fact, some of the advanced engineering——

SDI POWER SOURCES

Senator JOHNSTON. What is your power source? That is what I am trying to get at.

General ABRAHAMSON. Oh, the power source for that. The power source would have to be——

Colonel DAVIS. Well, for the space system, we are talking about hydrogen oxygen fuel cells or turbo alternators for a full-scale system.

General ABRAHAMSON. And those are difficult. In any experiment, we have got to be able to get up to very high power levels.

So that is the main activity at Los Alamos. But Los Alamos also does system studies. They run checks and counterchecks on the other laboratories. We always do that, having very important activities where we have the laboratories contribute, a sort of peer review activity, that is very helpful.

At Livermore, the real work is primarily in the [deleted]. They do systems analysis work for us. That has been very, very helpful. The picture on the right is the advanced test accelerator and the facility there that has given us most of the work in the Induction Linac version of the free electron laser. Now that is one that is quite different than the RF, and that is just one where you use an electron beam, build up that electron beam, and then convert the electron beam energy into the right frequency that you are after.

We have gone from very successful tests at microwave frequencies, which are not helpful to us. We have scaled down with this pallet and experiment, down to 10.6 microns. [Deleted.] So we have gone a long ways in our scaling, but we haven't done the final effort.

That scaling effort has been successful, but there are problems as we go through this part of the program.

SANDIA ACTIVITIES

At Sandia, there are many activities that are underway. Some of them are listed on the right. The Falcon Laboratory is the pulsed version of the nuclear reactor pumped laser that could operate in space.

We are also building a strategic defense facility there in conjunction with the Department of Energy, so this is jointly funded between our funds and the Department of Energy funds. And it was directed by the committees that it be jointly funded.

Now with that, those are our main efforts that are underway.

Again, I guess I would like to close by saying that I think that some of the people here are the nation's most important resource. These physicists are just wonderful. They are all free-spoken individuals. We run a program where we think that we will get the best self-correction by letting people do a lot of talking about their program and arguing about it. And that occurs in public as well, of course, as you know. And everyone of them believes very fiercely that they have the answer——

Senator JOHNSTON. Admiral, do you agree with that? [Laughter.]

Mr. FOLEY. Yes, sir.

I might as well stir the air just a little different. Senator McClure and I have discussed this in the past. I think the input of the laboratories and their scientists is absolutely essential to everything. It is just that the type of questions that you are asking right now, I know, requires a lot of detail and background and briefing and discussion with the experts out there in the labs.

My problem is getting an arm around that bunch of free spirits out there and teaching them in a businesslike manner. That is my only problem.

Senator MCCLURE. It is the question of what kind of balance you can get.

Mr. FOLEY. Yes, sir.

Senator MCCLURE. And I understand your problem.

General ABRAHAMSON. But nonetheless, we do try to run a self-corrective kind of program, and we do do a great deal of peer review. And even though sometimes it causes us, because there are different opinions, you know, different opinions among the scientists themselves, as well as different opinions about how the priorities in the program in all of them should be laid out.

We accept it. That's, in fact, one of the prices of doing business in a healthy way.

Senator JOHNSTON. That is good. I am glad to hear you say that.

EARLY SDI DEPLOYMENT ARCHITECTURE

General, in your letter to me of April 8, 1987, about the second SDI staff report which we had, you say, "The SDI does not have a black program developing a reference architecture for a near-term deployment strategic defenses upon."

A Defense-leak interview with one of your chief scientists, Dr. Alan Mentz, indicates that there is a highly classified study of the early deployment architecture. Even you indicated at a hearing on March 19 that there is a classified, near-term architecture that includes [deleted].

General ABRAHAMSON. The difference is between black and classified. When my people started one of their architectural studies, they proposed that it be handled in a compartment and looked at very, very carefully.

I reversed that final decision, and it is classified, of course, because it deals with effectiveness levels for certain levels as we go ahead.

The term "black" usually refers to compartmented, and we have no compartmented programs on these various architectures.

In fact, I have been, I think, fairly straightforward in, particularly in the classified testimony, but even in some of the unclassified testimony in explaining that we are talking about phased deployment, and we are looking at what some of these architectures, strawman architectures, might be for a phased deployment; that the first phase is indeed one——

Senator JOHNSTON. What do we mean by "strawman architecture"?

General ABRAHAMSON. A strawman architecture might be a number of weapons in a particular kind of an orbit based on a certain level of technology maturity, and based on a certain number of surveillance sensors and battle management concepts that go with it.

Senator JOHNSTON. Well, any deployment has got to be based on a certain number. But what is the meaning of it in terms of strawman? Is it hypothetical or does it mean——

General ABRAHAMSON. Yes, sir; it is hypothetical. And, in fact, we are going through a process now—and I commented on this in the authorization committee hearings—we are going through a process with the normal Defense Department process of validating requirements and going through milestones. And I am sure you are familiar with what used to be called the DSARC process. Now we call that the DAB process, Defense Advisory Board process.

We are going through a milestone 1 decision. Our strawman architecture was used to outline some of the issues, some of the capability levels, some of the problems that any of these kinds of systems composed of: [deleted].

The outcome of this DAB No. 1 milestone will be a requirement that will be more quantified by the JCS. That JCS requirement will then cause us to go back and to modify our first initial architecture, probably go through several of these. And it will be an interview process really from then on. But, clearly, it will be modifications to some of these initial strawman architecture.

RESTRICTED PROGRAM AREAS

Senator JOHNSTON. General, getting back to that letter and your answer, Mr. Mentz says—asked if it was right for officials to have given the answer that there was no black program. Mentz said, "Yes, I think that's right in some areas." And then he says, "There's people in Congress who aren't supposed to know some things." And then he says, "The near-term study was guarded by very restrictive access."

He further says, "If I don't have an answer to something yet, and I'm just exploring through it, I don't think I need to kind of cough up every little thing that I'm doing to some guy because he wants to come in and slow my program down. By the way, we don't tell our friends either. There is some right to privacy while we're investigating things."

Is that your view? [Laughter.]

General ABRAHAMSON. Sir, we run many, many alternative kind of strategies. We run many, many programs all the time. If there is a request to see some of those activities by members of your staff or any committee staff, I don't believe that we have denied those at all.

What we have done is that there are black programs in this overall effort. Those are primarily aimed at protecting certain technology, and we have not allowed all staff members access into every one of these particular technology protection programs. So there are varying levels of——

Senator JOHNSTON. Your answer is yes or no, Dr. Mentz was——

General ABRAHAMSON. Yes or no. We are going to——

Senator JOHNSTON. Well, frankly, General, it has been misleading.

General ABRAHAMSON. Yes.

Senator JOHNSTON. It has been very misleading.

I think your answer was very misleading when we asked you if there was a black program, and you said "No."

General ABRAHAMSON. That's right; there isn't.

Senator JOHNSTON. Now you are telling us there is a difference between a black program and a restricted program and it's been given out to the public here that there is no secret architecture, that the public knows everything that is supposed to be known about plans to deploy. And I think that is misleading. And I think that Dr. Mentz says, "Yeah, we lied, but we've got a right to lie." And I am highly offended with this.

General ABRAHAMSON. OK. I understand that. I don't like the way he said any of that. In fact, there are lots of studies about various different kinds of programs. And I don't believe that we have ever lied and are lying about this program itself.

Now in terms of how much all of that's shared, you know, I don't go out and publicly talk about the number or performance things that must and should be classified. But I think that we have been very forthcoming in terms of describing what the components of a first-phase deployment might be, even publicly, and in the open hearings.

STATUS OF EARLY DEPLOYMENT DECISION

Senator JOHNSTON. What is the current status of plans for what are called an early deployment of a space-based KKV or for a decision on that deployment?

General ABRAHAMSON. I think that the current status is exactly what I have said and what the Secretary of Defense has said, and that is we are thinking through what a phased deployment means.It is natural and reasonable that a phased deployment would have certain characteristics and would not be fully capable as you go through.

General ABRAHAMSON. I have tried in an unclassified way to describe in open hearings the technologies involved in those phased deployments.

General ABRAHAMSON. I used in an unclassified way to describe the elements——

Senator JOHNSTON. Would you put up that first chart there?

General ABRAHAMSON. Yes, sir.

DEVELOPMENT AND DEPLOYMENT DECISIONS

Senator JOHNSTON. Now you've got development and deployment decisions.

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. Now I know about the phases.

General ABRAHAMSON. Right.

Senator JOHNSTON. What is the status of making a development and deployment decision?

General ABRAHAMSON. There is no decision to go ahead. The status is that we are working very hard toward a DAB milestone 1, which is a normal Department of Defense milestone, which is not a go-ahead. A milestone 1 is normally provided in the research phase of a program. What it does is that it validates the requirement, the military requirement, the size and shape of that military requirement. That milestone 1 decision process is one that we're embarked on and that I have testified, and said quite openly that we're aiming for the June to July timeframe.

Senator JOHNSTON. June to July of this year?

General ABRAHAMSON. Yes, sir. A go-ahead of the kind that I mean here when I say a development and deployment decision is usually associated with a milestone 2 kind of DAB review. That is not scheduled. It is not timed. We know that there are a great number of milestones and things that have to be gone through in order to get there. We are going to go through that as fast as we can. But there isn't a timeframe.

Senator JOHNSTON. Well, milestone 1 would be to evaluate technologies.

General ABRAHAMSON. Yes, sir; it does one further thing. It outlines the requirement more specifically, and, furthermore, there are two things that are delivered there. One is called a development concept paper, which deals primarily with the requirement. And then it also says how you are going to proceed through the next step getting up to your milestone 2 decision. That step is usually called validation, and it is a lot of test requirements that are a part of that.

Senator JOHNSTON. And milestone 2 would be the development and deployment decision?

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. And what kind of timeframe are we talking about between milestone 1 and milestone 2?

General ABRAHAMSON. And milestone 2. That is always hard to say. What I said quite consistently is that depending on what our funding is, I still believe that for a phase 1 portion of such a system that can be made by the early 1990's. If we can make it faster than that, we will do that. My direction is to be ready and to move as quickly as we can.

The Secretary has put it, I think, accurately when he says that we will deploy. We are aiming our research at a deployment program. I think the President has indicated he is aiming this research effort to deploy. It is not research for research's only sake.

Senator JOHNSTON. I am trying to get this date to understand the decision.

General ABRAHAMSON. Yes.

Senator JOHNSTON. Milestone 2, you are talking about would occur in the early 1990's.

General ABRAHAMSON. Yes, sir; that is what I have said consistently. I have also said that if we can make it earlier than that, we would do that. I don't know how much earlier it could be.

I have got reports on my desk that show maybe we could do it in 1992, maybe we could do it in 1990. I would like to be in a position to make it earlier than that if I could.

Senator JOHNSTON. Well, the PRDA, which you wrote, I understand, talks about the 1988–89 timeframe.

General ABRAHAMSON. No, sir. That PRDA is for a heavy lift launch vehicle—that's an enabling kind of technology. And what it says is that if there were a decision for it to go ahead with a heavy lift launch vehicle in the 1988 or 1989 timeframe, that that would—what kind of a technology would you be able to then incorporate and gradually build to a long-term——

Senator JOHNSTON. Well, let me interject here. Specifically, the design concept—we are talking about a heavy lift launch vehicle—should provide a partial capability to substantially reduce costs by the 1994 timeframe.

General ABRAHAMSON. Right.

Senator JOHNSTON. Should a national decision to implement the initial operating capability of the strategic defense performance be made by 1988 or 1989?

General ABRAHAMSON. Right.

Senator JOHNSTON. And this is the PRDA.

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. And that was written by you.

General ABRAHAMSON. Yes, sir; it was.

Senator JOHNSTON. Now how could you be talking about a 1988 or a 1989 timeframe?

General ABRAHAMSON. Very specifically, that is such an important technology, and there is enough of a leadtime required for that, that what I was trying to do is to preserve the option so that if a decision were made to go ahead for any purpose at all, that you would like to be able to tell those contractors the timeframe so that they would know that from 1988 or 1989 or somewhere in that timeframe they have between then and 1994 to come up with an interim capability, and what could you do——

Senator JOHNSTON. I understand what you are telling them. I understand those leadtimes which I think, by the way, are greater than stated there, at least if past technology development times are true. Nevertheless, you say we are talking about the early 1990's, and yet there is a possibility here of 1988.

Now could you tell me how you could possibly make that decision in 1988, how you could make it?

General ABRAHAMSON. Frankly, I think it is very unlikely that we could make such a decision in 1988. If we could, if it were required on a national basis, then you want to be in a position to be able to go as fast as you can with the program, obviously.

Senator JOHNSTON. Well, if you made it in 1988, wouldn't that be, by definition, premature?

General ABRAHAMSON. Based on the technology and where we are at this point, the answer would be "Yes." There's a lot of work yet to be done.

Senator JOHNSTON. How could it conceivably be made in 1988?

General ABRAHAMSON. I don't know. But if we had the ability to make some of the progress that we are making, and if that were looked at, and it were made, and it were made in the normal way that you make these kinds of decisions—you go through a DAB kind of milestone—frankly, I don't believe it would be done without coming to the Congress.

My job is to make this come as fast as possible within the resources, and as reasonable as possible. And that is what I am trying to do.

Senator JOHNSTON. Well, I understand.

General ABRAHAMSON. The important thing is at no level, neither in my mind nor in the Secretary of Defense's mind, and certainly I don't believe in the President's mind, is there any kind of a thing that says, yes, we ought to be able to make this right now at this point in time. There is a lot of technology that has to be done.

Senator JOHNSTON. In effect, it would be necessarily, almost by definition, premature if made in 1988.

General ABRAHAMSON. At this point, based on the technology that I know and see, the answer would be "Yes."

Senator JOHNSTON. And what could conceivably happen in 1988 to change your view of that?

General ABRAHAMSON. It would depend on the kinds of technology advances that we made between now and then. Obviously, this decision is one that should not be made only in the context of the technology. It also has to be made in the context of what is the world and what's the threat that's out there.

Senator JOHNSTON. If the threat increased—give me a scenario that you could make a decision in 1988.

General ABRAHAMSON. I think the one that goes back to exactly what the direction that the President laid out, and that was to have a defensive option in case the Soviets broke out. If the Soviets broke out of the ABM Treaty, then certainly I think everybody in this nation would want us to look at a whole variety of options. And I have testified in the past that I believe——

FACTS AFFECTING AN EARLY DEPLOYMENT DECISION

Senator JOHNSTON. Oh, I certainly want you to look at options. But we are talking about narrowing the options to develop a decision.

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. And what I am——

General ABRAHAMSON. And I have a responsibility to try to carry what a set of those options might look like, and that is what I am doing.

Senator JOHNSTON. Well, General, we are talking about narrowing the options. What could conceivably happen in 1988? In other words, I don't want to wake up one morning in October or November and find that a decision has been made, and say, "Oh, you know, in April, that was premature. But now it is October and things have changed." And I want to know what could change. I mean, have you got any test plan that if you prove out a certain theory or a certain piece of equipment or—I asked the question in the context that we had the three lab directors testify, and all agreed that a decision would be premature before the early 1990's.

General ABRAHAMSON. Yes. Those three lab directors are obviously talking about—what they learned from their technology base—in terms of both, some of their systems studies, which——

Senator JOHNSTON. I know what they said and how they said it, but what do you say?

General ABRAHAMSON. All right. This is what we are looking at. We are not looking at any directed energy kinds of concepts in the first phase.

Senator JOHNSTON. We are not looking at any.

SPACE-BASED INTERCEPTOR

General ABRAHAMSON. That's right.

I believe that the key to the whole process would be, if we made an engineering progress, and somehow were able to test this space-based interceptor, in particular in boost phase, and you say that you had sufficient confidence with the space-based interceptor, and that you could build such a thing, and build it at the rate-cost level, and it would be militarily effective——

Senator JOHNSTON. But there's no test plan. There's no budget request. There's no conceivable way that could be done in fiscal year or calendar year 1988, is there?

General ABRAHAMSON. Right now there is not such a test that we are looking at. I owe the President something, a report that is due the end of this month that says if we had additional freedom to test, what kind of thing would you do? We are trying to look at what that additional freedom to test might allow us to do.

Senator JOHNSTON. What kind of tests would those be?

General ABRAHAMSON. It would be with the space-based interceptor.

Senator JOHNSTON. Space based.

General ABRAHAMSON. That's correct.

And could we do that in that space of time? Probably not; it is very chancy. Would we try? Yes; we would try to——

Senator JOHNSTON. That would be a necessary test in order to make the decision.

EFFECTIVENESS OF SPACE-BASED INTERCEPTORS

General, in our staff report, it says that near-term deployment would have an effectiveness of no more than 16 percent. Your rebuttal letter did not address that number. Your briefing charts show that the first phase of deployment would disrupt the timing of a Soviet attack.

What does that mean in terms of warheads destroyed and warheads getting through in the boost phase, mid-course and terminal phases?

General ABRAHAMSON. It always depends on a whole series of assumptions. We have had several of those reports and those studies that talk about levels as low as 30 percent, some that would be higher than that.

Senator JOHNSTON. Thirty percent?

General ABRAHAMSON. Yes, sir; and some that would be slightly lower than that. But the key issue that I keep trying to make is that I don't believe that in an initial phase that it's the percentage of warheads that you stop. I think that the real issue is, in fact, how does that restrict the Soviets' ability to pull off a surprise attack, or to, in fact, do something more dramatic?

Senator JOHNSTON. Well, I understand what it means, but let me get to the numbers, if I may.

General ABRAHAMSON. Yes.

That is based on a certain number of space-based kenetic kill vehicles, assumptions about how effective they will be, how many you have in orbit, all of those numbers. Those can and probably will change.

Senator JOHNSTON. Can you give me what you consider to be some of your likely scenarios with numbers of vehicles or buses, number of rockets?

General ABRAHAMSON. I have already done that in testimony, and I indicated that at least one of the strawman architectures in the studies that were done was based on [deleted] in low Earth orbit. With those [deleted] the studies were done based on [deleted] interceptors that were in those. Those are numbers, and it varied on the order of there was some less, some a little more. Depending on the kind of structure of an attack the Soviets made, based on——

Senator JOHNSTON. Those are [deleted]. And you would kill 30 percent.

General ABRAHAMSON. Yes, on that order. And it depends on the structure of the attack. If they all come from the Soviet SS–18 fields; for example, first, you get one result. If some of them come from some of the 19 fields or the other fields, you get a different result.

Senator JOHNSTON. The 30 percent is not a total, but of the first wave.

General ABRAHAMSON. Yes, sir; we are considering what a first-wave structure might look like.

Senator JOHNSTON. And you say the first wave of, maybe, the SS–18's?

General ABRAHAMSON. We consider that the one that you would like to deal with and that would have the first priority would be the heavies, which are the 18's now, and will be the 24's in the future. So that those are very, very critical ones.

Now here is a good example of exactly the way we begin to use these systems and how we use these strawman studies. As I looked at that, and then as I began to say, OK, what happens when they begin to use countermeasures? We put forward a large number of SS–20 kind of countermeasures, and we said we have to modify this. We have to add some interceptors, and we have to add capability to the overall system. So I added [deleted] and for the next set of studies I have added two more missiles for each carrier vehicle.

By the time the Joint Chiefs of Staff finish this process over the next several months, it will probably look different again. But that is the point of doing these straw-type of studies and redoing them time and time again and doing the simulations.

COST OF NEAR-TERM DEPLOYMENT

Senator JOHNSTON. Now the $40 to $60 billion cost of the first phase of a near-term deployment, was that on the [deleted].

General ABRAHAMSON. That was based on [deleted] vehicles. And at the time that I gave that number, I indicted, and I qualified it, by saying that that was based on a particular study with [deleted] vehicles estimated with the number of carrier vehicles, and, and if I remember right, something like [deleted] that went along with it. I think [deleted] something like that.

Those are a specific set of——

Senator JOHNSTON. [Deleted] satellites?

General ABRAHAMSON. I think so if I remember correctly; is that correct?

Colonel DAVIS. Yes, sir.

General ABRAHAMSON. But they have a whole series of assumptions that go with that.

OFFENSIVE AND DEFENSIVE APPLICATION OF SDI

Mr. FOLEY. Mr. Chairman, I have one rather general question, and I don't expect a detailed answer, but I would invite you to submit further information that you would like as to how much of what we are doing in SDI is directed against anticipating the ability of space-based vehicles to launch attacks against Earth targets.

General ABRAHAMSON. You mean Soviet systems——

Mr. FOLEY. Yes.

General ABRAHAMSON [continuing]. Launched against our Earth targets?

Mr. FOLEY. Yes.

General ABRAHAMSON. Frankly, not very much.

Mr. FOLEY. All right.

And how much credibility is there——

General ABRAHAMSON. Only in the way that there is an inherent ASAT capability. If you can shoot down a warhead in flight, you can shoot down an ASAT.

Mr. FOLEY. How much credibility should we give to those who charge that an SDI is not defensive but is inherently capable of offensive characteristics?

General ABRAHAMSON. Well, there are two levels at which that charge is made. And the first level, I think, is you shouldn't give much credibility to it. It is, can you use some of these space-based weapons offensively? And I think what they mean by that, or at least what I have shown they mean, is against targets on Earth, mass destruction kinds of thing. They have talked about starting many fires in the Soviet Union with lasers, or using some of these space-based interceptors to hit targets on Earth. I think that is not credible hardly at all, frankly. It is not a reasonable strategy for space-based interceptors. You don't want to put heat shields on them because it is just going to cost a lot more to get them up there. Just so that you can get them down.

Could you ever use such a thing against airplanes, for example? A specially designed one might be useable against an airplane, but it requires a special design.

There is another kind of answer to that, some would say, and this I think is the Russian concern, that if you could hide behind a defense, and make a strike with your offensive weapons, in that sense it could be used as part of an overall defensive strategy. I think that is one we should be worried about.

Mr. FOLEY. Thank you very much, Mr. Chairman. Thank you, General.

General ABRAHAMSON. Thank you.

Senator JOHNSTON. General, if I may break in. Dr. Barker has got to leave at noon, and he has a short statement he would like to make.

Before you begin, Doctor, may I ask—I was just reading your statement—the B-54Y1 has a yield of [deleted] kilotons. Is that that [deleted].

Dr. BARKER. No; the SADM is a special atomic demolition munition.

Senator JOHNSTON. Oh, yes. We phased out those that had yields of about [deleted] of the [deleted] didn't we?

Dr. BARKER. The [deleted] are still there. They are about [deleted] systems, and we are still taking them out. [Deleted.] So as much as we would like——

Senator JOHNSTON. We really don't know how much we would get out of those things.

Dr. BARKER. Well, the Department of Energy certifies to us that they will produce [deleted].

Mr. FOLEY. But we would like to remove those for other reasons from the stockpile and replace them with something more modern—from a safety viewpoint entirely. We think we have a much better weapon now and we would like to get the old ones out of the stockpile.

Senator JOHNSTON. I agree.

STATEMENT OF DR. ROBERT B. BARKER, ASSISTANT TO THE SECRETARY OF DEFENSE (ATOMIC ENERGY), DEPARTMENT OF DEFENSE

PREPARED STATEMENT

Dr. BARKER. I appreciate the opportunity to testify on behalf of the Secretary of Defense in support of the rest of the DOE budget. I have submitted a prepared statement for the record.

[The statement follows:]

STATEMENT OF HON. ROBERT B. BARKER

(U) MR. CHAIRMAN, MEMBERS OF THE COMMITTEE, I AM PLEASED TO HAVE THIS OPPORTUNITY TO PRESENT THE VIEWS OF THE DEPARTMENT OF DEFENSE IN SUPPORT OF THE DEPARTMENT OF ENERGY'S PROPOSED FISCAL YEARS 1988 AND 1989 NUCLEAR WEAPONS PROGRAM. THIS IS MY FIRST APPEARANCE BEFORE YOU AS THE ASSISTANT TO THE SECRETARY OF DEFENSE FOR ATOMIC ENERGY AND STAFF DIRECTOR OF THE NUCLEAR WEAPONS COUNCIL.

(U) I HAVE ACCEPTED MY POSITION AND THE RESPONSIBILITIES ASSOCIATED WITH IT DURING WHAT I VIEW AS A CRITICAL PERIOD OF THE UNITED STATES' NUCLEAR WEAPONS PROGRAM. THE PERCEPTION OF INADEQUATE FISCAL ACCOUNTABILITY AND DISCIPLINE IN THE NATION'S NUCLEAR WEAPONS PROCUREMENT PROGRAM LED TO THE FORMATION OF THE BLUE RIBBON TASK GROUP (BRTG) ON NUCLEAR WEAPONS PROGRAM MANAGEMENT. THIS GROUP, CHAIRED BY JUDGE CLARK, CONCLUDED THAT BY-AND-LARGE THE SYSTEM WAS NOT "BROKE." BUT IT DID MAKE SEVERAL RECOMMENDATIONS. THE CONGRESS, BY ESTABLISHING THE NUCLEAR WEAPON COUNCIL AND ELIMINATING THE MILITARY LIAISON COMMITTEE, HAS IDENTIFIED THAT IT WANTS CHANGES. I BELIEVE THAT MUCH OF THE CONCERN THAT LED TO THE CREATION OF THE BLUE RIBBON TASK GROUP WAS BASED ON "PERCEPTION" AND NOT "REALITY." BUT THE DoD JOINS WITH THE DOE IN BEING CONCERNED THAT THERE WAS EVEN THE PERCEPTION OF INADEQUATE ACCOUNTABILITY. THE TWO DEPARTMENTS SHARE THE COMMITMENT TO WORK TOGETHER IN WAYS THAT WILL DEMONSTRATE THAT PROGRAMMATIC REQUIREMENTS WILL CONTINUE TO BE WEIGHED CAREFULLY AGAINST THEIR FISCAL IMPACTS.

(U) AMERICA'S BASIC DEFENSE STRATEGY, AS IT HAS BEEN FOR THE ENTIRE POSTWAR PERIOD SINCE WW II, IS DETERRENCE. IN THE HANDS OF THE UNITED STATES AND IN THE SERVICE OF OUR ALLIANCES, NUCLEAR WEAPONS HAVE BEEN A POWERFUL AND COST EFFECTIVE FORCE

FOR DETERRING AGGRESSION. SINCE THE BEGINNING OF THE NUCLEAR ERA, AMERICAN STRATEGIC THOUGHT HAS STRESSED THE IMPERATIVES OF DETERRING NUCLEAR WAR--DISSUADING OUR ADVERSARIES BY THE THREAT OF RETALIATION FROM EVER USING NUCLEAR WEAPONS AGAINST THE UNITED STATES, OUR ALLIES, OR OUR FRIENDS. OUR DEFENSE POLICY ALSO RELIES ON U.S. NUCLEAR WEAPONS TO DETER CONVENTIONAL ATTACKS. THE CORNERSTONE OF OUR DETERRENT POSTURE IS OUR NUCLEAR WEAPONS CAPABILITY. THIS CORNERSTONE HAS SERVED OUR NATION WELL. FOR OVER FOUR DECADES, THE U.S. NUCLEAR UMBRELLA HAS AVERTED WAR ON A GLOBAL SCALE--A CHALLENGE WHICH CONVENTIONAL FORCES FAILED TO ACCOMPLISH DURING THE FIRST HALF OF THIS CENTURY.

(U) NEITHER THE PROMISE OF STRATEGIC DEFENSE NOR THE PROSPECTS FOR DEEP ARMS REDUCTIONS OBVIATE THE NEED TO MAINTAIN A NUCLEAR DETERRENT AND TO KEEP OUR NUCLEAR DETERRENT STRONG AND RESPONSIVE TO THE CHANGING THREAT. FOR THE FORESEEABLE FUTURE, WE MUST MAINTAIN A MODERN AND CREDIBLE NUCLEAR DETERRENT--A REQUIREMENT THAT MANDATES NOT ONLY ADEQUATE FORCES AND EFFECTIVE PLANS FOR THEIR USE, BUT ALSO EFFECTIVE COMMAND, CONTROL, COMMUNICATIONS, AND INTELLIGENCE (C^3I), AND RELIABLE, SAFE WARHEADS.

(U) I BELIEVE IT IS USEFUL TO REEXAMINE THE MISSION AND BROAD REQUIREMENTS PLACED ON THIS COUNTRY'S NUCLEAR WEAPONS PROGRAM IN SUPPORT OF OUR NATIONAL SECURITY. IN THE AREA OF RESEARCH, DEVELOPMENT, AND TESTING (RD&T), THE REQUIREMENTS ARE BEST STATED BY SEVERAL OF THE SAFEGUARDS WHICH THE SENATE WISELY INCORPORATED AS PART OF RATIFICATION OF THE LIMITED TEST BAN TREATY IN 1963:

- (U) THE CONDUCT OF COMPREHENSIVE, AGGRESSIVE, AND CONTINUING UNDERGROUND NUCLEAR TEST PROGRAMS DESIGNED TO

ADD TO OUR KNOWLEDGE AND IMPROVE OUR WEAPONS IN ALL AREAS OF SIGNIFICANCE TO OUR MILITARY POSTURE FOR THE FUTURE.

- (U) THE MAINTENANCE OF MODERN NUCLEAR LABORATORY FACILITIES AND PROGRAMS IN THEORETICAL AND EXPLORATORY NUCLEAR TECHNOLOGY WHICH WILL ATTRACT, RETAIN, AND ENSURE THE CONTINUED APPLICATION OF OUR HUMAN SCIENTIFIC RESOURCES TO THOSE PROGRAMS ON WHICH CONTINUED PROGRESS IN NUCLEAR TECHNOLOGY DEPENDS.

(U) IN 1979, THE JOINT DEPARTMENT OF DEFENSE/DEPARTMENT OF ENERGY (DoD/DOE) LONG RANGE RESOURCE PLANNING GROUP, DIRECTED BY LIEUTENANT GENERAL (RETIRED) ALFRED D. STARBIRD, WAS ESTABLISHED TO DEVELOP AND PROPOSE GUIDANCE FOR A 20-YEAR NUCLEAR WEAPON PROGRAM, INCLUDING, IN PART, RESOURCE PLANNING FOR RD&T, PRODUCTION, MATERIALS, MANPOWER, AND FUNDING. THE STUDY WAS DIRECTED TO CONSIDER THE NEEDED FABRICATION AND ASSEMBLY PLANT CAPACITIES, THE NUCLEAR MATERIALS PRODUCTION CAPACITIES, THE NEED FOR ANY OTHER SPECIAL MATERIALS THAT COULD BE IN SHORT SUPPLY, AS WELL AS THE REQUIREMENTS TO MODERNIZE PRODUCTION PLANTS AND TESTING AND RESEARCH FACILITIES. IT WAS FURTHER DIRECTED TO DEVISE GUIDANCE ADEQUATE TO DEVELOP BALANCED RESEARCH, DEVELOPMENT, NUCLEAR TESTING, NONNUCLEAR TESTING, WEAPONIZATION, AND PRODUCTION PROGRAMS FOR THE NATION'S NUCLEAR WEAPONS SYSTEMS, CONSIDERING NEEDS FOR ALL OF THE CRUCIAL ELEMENTS THAT ARE REQUIRED TO MAINTAIN CONFIDENCE IN OUR NUCLEAR DETERRENT.

(U) WHILE SOME OF THE SPECIFIC STARBIRD STUDY RECOMMENDATIONS ARE NOW OUTDATED, THE GENERAL THRUST IS STILL RELEVANT TO DETERMINING REQUIREMENTS NECESSARY TO MAINTAIN A CREDIBLE LONG-TERM NUCLEAR DETERRENT. IN SUMMARY, THE STARBIRD

STUDY RECOMMENDED THAT A VIBRANT ONGOING NUCLEAR WEAPONS PROGRAM SHOULD BE FOUNDED ON THE FOLLOWING:

- (U) FOR THE PRODUCTION COMPLEX, THE MAJOR FACTOR IN RESEARCH PLANNING IS THE PRESERVATION OF A CAPABILITY TO MANUFACTURE NUCLEAR WEAPONS AND TO MAINTAIN THE STOCKPILE. THIS REQUIRES THE MAINTENANCE OF SPECIALIZED PLANTS AND FACILITIES CAPABLE OF HANDLING PEAK DEMAND FOR WEAPON MANUFACTURE, AND A POOL OF EXPERIENCED PERSONNEL.

- (U) FOR THE SPECIAL NUCLEAR MATERIAL COMPONENT, THE PRINCIPAL FACTORS AFFECTING RESOURCE PLANNING ARE (1) THE NEED TO REPLACE TRITIUM PERIODICALLY IN ORDER TO KEEP THE STOCKPILE OPERABLE, AND/OR (2) THE VERY LONG LEAD TIMES AND RELATIVELY HIGH COSTS ASSOCIATED WITH OBTAINING ADDITIONAL PLUTONIUM, TRITIUM, AND HIGHLY ENRICHED URANIUM.

- (U) FOR THE RD&T COMPONENT, THE MOST VITAL ASSET IS THE POOL OF TRAINED AND EXPERIENCED SCIENTISTS AND ENGINEERS AND THE SPECIALIZED FACILITIES THEY USE. THERE IS NO INDUSTRIAL OR ACADEMIC COUNTERPART ELSEWHERE IN THE U.S. FOR MANY OF THESE CAPABILITIES. PEOPLE EXPERIENCED IN NUCLEAR WEAPON DESIGN CANNOT BE REPLACED EASILY OR QUICKLY. THUS, A PRIME FACTOR IN-RD&T RESOURCE PLANNING IS TO ENSURE THE STABILITY OF THIS WORK FORCE BY PROVIDING SUFFICIENT CHALLENGE AND INCENTIVES TO RETAIN EXPERIENCED PERSONNEL AS WELL AS TO RECRUIT NEW TALENT.

(U) THE DoD BELIEVES THAT THESE BROAD REQUIREMENTS IDENTIFIED BY THE 1979 STARBIRD STUDY ARE STILL VALID, AND WE SEEK CONGRESSIONAL SUPPORT TO ACHIEVE THE LONG-TERM OBJECTIVES

OF THE NUCLEAR WEAPONS PROGRAM AND PROVIDE FUNDING NECESSARY TO MAINTAIN STABILITY IN SUPPORTING THOSE OBJECTIVES.

(U) THE DOE NUCLEAR WEAPONS PROGRAM IS A NATIONAL ASSET WHICH CONTRIBUTES TO OUR NATIONAL DEFENSE IN WAYS BEYOND ITS PRIMARY MISSION OF DEVELOPING AND PRODUCING NUCLEAR WEAPONS. THE CORE OF EXPERIENCE PROVIDES SPINOFF BENEFITS, OTHERWISE UNAVAILABLE, TO THE DoD. A GOOD EXAMPLE IS THE ACTIVITY, PRIMARILY AT SANDIA NATIONAL LABORATORY, TO DEVELOP NEW TECHNOLOGIES TO IMPROVE THE SECURITY OF NUCLEAR WEAPONS AND NUCLEAR MATERIAL IN DOE CUSTODY. BECAUSE OF THE CAPABILITIES AND EXPERTISE DEVELOPED IN THE DOE PROGRAM, THE DoD HAS BEEN ABLE TO IMPROVE ITS OWN SECURITY POSTURE BY REQUESTING DOE TO TAKE THE INITIATIVE IN IDENTIFYING USEFUL IMPROVEMENTS. THIS RELATIONSHIP HAS PRODUCED, FOR THE DoD, INTRUSION DETECTION SYSTEMS, WEAPON ACCESS DELAY SYSTEMS, WEAPON STORAGE VAULTS FOR BOMBS, AND OTHER IMPROVEMENTS. SANDIA IS CURRENTLY WORKING WITH THE DEFENSE NUCLEAR AGENCY TO DEVELOP THE MEANS TO COUNTER WARSAW PACT AND TERRORIST THREATS TO THE DoD NUCLEAR STOCKPILE IN THE 21ST CENTURY.

(U) THIS IS JUST ONE EXAMPLE OF THE VALUE OF A STRONG DOE RD&T CORE PROGRAM, WHOSE EXPERIENCE AND LEVEL OF COMPETENCE PROVIDE ASSISTANCE TO OTHER AGENCIES.

(U) DURING THE LAST DECADE, AN OUTGROWTH OF EXPLORATORY RESEARCH HAS BEEN NUCLEAR-DRIVEN DIRECTED ENERGY WEAPONS (NDEW). THE DOE NUCLEAR-DRIVEN DIRECTED ENERGY WEAPON ACTIVITY IS CRUCIAL IN ORDER TO DETERMINE THE FEASIBILITY AND EFFECTIVENESS OF SUCH SYSTEMS WHEN USED AGAINST FUTURE U.S. SURVEILLANCE AND DEFENSIVE SYSTEMS, AS WELL AS AGAINST OUR PRESENT DETERRENT FORCES. THIS EFFORT TO EVALUATE A POTENTIAL THREAT WOULD BE NEEDED EVEN WITHOUT A U.S. SDI PROGRAM. HOWEVER, MAINTAINING THE DOE SDI-

RELATED ACTIVITY ON A SCHEDULE CONSISTENT WITH SDI MILESTONES IS A SIGNIFICANT EXPANSION OF DOE'S TRADITIONAL AND ONGOING RD&T RESPONSIBILITIES.

(U) IT IS THEREFORE ESSENTIAL TO MAINTAIN THE TRADITIONAL RD&T PROGRAM IN SUPPORT OF OUR DETERRENT POSTURE WHILE PROVIDING THE ADDITIONAL FUNDING REQUESTED BY DOE TO SUPPORT DOE'S SDI-RELATED ACTIVITY. IN ORDER TO MAINTAIN STABILITY IN THE TRADITIONAL PROGRAM, WHILE PROVIDING FOR A DOE SDI-RELATED ACTIVITY CONSISTENT WITH DoD MILESTONES, THE TWO DEPARTMENTS--DoD AND DOE--AGAIN REACHED AGREEMENT ON THE NEED TO AUGMENT, PRIOR TO SUBMITTING THE PRESIDENT'S BUDGET TO THE CONGRESS, THE DOE FY88 REQUEST, AS WAS DONE IN THE FY87 REQUEST, AT THE EXPENSE OF DECREMENTING THE PRESIDENT'S DoD BUDGET. THE BUDGET REQUEST BEFORE YOU REFLECTS SUCH AUGMENTATION. I URGE THE CONGRESS TO CONSIDER DURING ITS DELIBERATIONS THE COMMITMENT THAT THIS AUGMENTATION REPRESENTS BY THE DoD TO BOTH MISSIONS--TRADITIONAL RD&T AND SDI-RELATED RESEARCH.

(U) I WOULD NOW LIKE TO ADDRESS THE RECOMMENDATIONS OF THE PRESIDENT'S BLUE RIBBON TASK GROUP (BRTG). THE GROUP WAS CHARTERED TO EXAMINE THE PROCEDURES USED BY DoD AND DOE IN ESTABLISHING REQUIREMENTS, AND PROVIDING RESOURCES FOR, THE RESEARCH, DEVELOPMENT, TESTING, PRODUCTION, SURVEILLANCE, AND RETIREMENT OF NUCLEAR WEAPONS AND TO RECOMMEND ANY NEEDED CHANGE IN COORDINATION, BUDGETING, OR MANAGEMENT PROCEDURES. SOME OF THE RECOMMENDATIONS WERE PUT IN PLACE BY THE NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1987, SECTION 3137, "IMPLEMENTATION OF THE RECOMMENDATIONS OF THE PRESIDENT'S BLUE RIBBON TASK GROUP ON NUCLEAR WEAPONS PROGRAM MANAGEMENT," WHICH ESTABLISHED A JOINT NUCLEAR WEAPONS COUNCIL (NWC). THE NWC HAS SUBMITTED A REPORT TO CONGRESS ON THE ACTIONS THAT HAVE BEEN TAKEN BY THE TWO DEPARTMENTS TO IMPLEMENT THE BRTG RECOMMEN-

DATIONS. I WILL NOT ADDRESS EACH OF THE RECOMMENDATIONS NOW. I SUPPORT THE OVERALL THRUST OF THE BRTG RECOMMENDATIONS. I ALSO SUPPORT STRONGLY THE TASK GROUP CAUTION THAT "ADOPTING MORE DRASTIC MEASURES TO IMPROVE COST CONSCIOUSNESS AND ACCOUNTABILITY COULD UPSET THE DELICATE BALANCE BETWEEN COMPETING CONCERNS. IT IS IMPORTANT THAT COST CONTROL PROCEDURES NOT CUT CORNERS IN CRITICAL AREAS SUCH AS NUCLEAR SAFETY OR INHIBIT THE INNOVATIVE AND AGGRESSIVE TECHNOLOGY BASE ACTIVITIES."

(U) WITH REGARD TO THE NUCLEAR WEAPONS DEVELOPMENT PROCESS AND THE RESULTING PRODUCTION REQUIREMENTS, I BELIEVE WE HAVE ESTABLISHED AN ORDERLY SYSTEM WHICH ASSURES THAT THE DEVELOPMENT PROCESSES OF THE TWO DEPARTMENTS ARE SYNCHRONIZED. THIS SYSTEM IS BASED ON INTERDEPARTMENTAL AGREEMENTS, WHICH ARE IMPLEMENTED WITHIN DoD BY DIRECTIVES AND INSTRUCTIONS. IT IS DoD POLICY THAT NUCLEAR WEAPON CONCEPT DEFINITION AND FEASIBILITY STUDIES AND DEVELOPMENT ENGINEERING PROJECTS SHALL CONSIDER TOTAL WEAPON SYSTEM COST AND PERFORMANCE IN ESTABLISHING MILITARY REQUIREMENTS AND DESIGN OBJECTIVES. FURTHER, PHASE 2 JOINT FEASIBILITY STUDIES ARE REQUIRED TO ADDRESS THE USE OF EXISTING ASSETS BY RESPONDING TO THE FOLLOWING QUESTIONS:

- WHAT NUCLEAR DEVICES IN PRODUCTION OR UNDER DEVELOPMENT APPEAR TO MEET THE REQUIREMENTS?
- WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF EACH?

(U) BOTH DEPARTMENTS ARE WELL AWARE OF THE LIMITED RESOURCES OF THE NUCLEAR WEAPONS PROGRAM AND THE NEED FOR CAREFUL CONSIDERATION OF THE ALLOCATION OF THESE RESOURCES. THE SYSTEM SHOULD BE FREE TO STUDY AND DETERMINE THE MOST COST EFFECTIVE OPTIONS FOR FUTURE SYSTEMS. WE HAVE AN OBLIGATION TO EXAMINE ALL POSSIBILITIES IN ORDER TO ASSURE THE BEST USE OF OUR LIMITED RESOURCES. I PLEDGE TO YOU THAT ANY DECISION TO PRODUCE AND

DEPLOY NEW SYSTEMS WILL RECEIVE CAREFUL REVIEW WITHIN THE EXECUTIVE BRANCH. I AM CONFIDENT THE SAME WILL BE TRUE IN THE LEGISLATIVE BRANCH.

(U) AS A PART OF MY TESTIMONY, I PLAN TO ANNUALLY UPDATE YOU ON THE STATE OF THE STOCKPILE.

THE STOCKPILE HAS DECLINED FROM APPROXIMATELY Deleted THE CURRENT STOCKPILE OF WARHEADS. IN THE CURRENT PLAN, ABOUT Deleted WARHEADS WILL BE BUILT Deleted DURING FY 1987-1992.

Deleted TO THE MODERNIZATION OF THE STRATEGIC OFFENSIVE FORCES, PRINCIPALLY THE PEACEKEEPER, TRIDENT II AND CRUISE MISSILE PROGRAMS, Deleted NEGOTIATIONS COULD PERMIT RETIREMENT OF THESE OLDER WARHEADS.

ALTHOUGH MODERNIZATION IS CONTINUING FOR THE NONSTRATEGIC FORCES, RETIREMENT OF OLDER WARHEADS Deleted Deleted STOCKPILE WARHEADS PLANNED FOR RETENTION WILL BE REVIEWED ANNUALLY BY THE DEPARTMENT OF DEFENSE AND THE DEPARTMENT OF ENERGY TO ENSURE THEIR CONTINUED SAFETY, SECURITY, AND RELIABILITY.

(U) DURING THIS ADMINISTRATION ONE-THIRD OF THE STOCKPILE HAS BEEN MODERNIZED WITH RESPECT TO USE CONTROL AND MODERN NUCLEAR SAFETY DESIGN CRITERIA: INSENSITIVE HIGH EXPLOSIVE

(IHE), NON-VIOLENT DISABLEMENT, SAFE PREDICTABLE ACCIDENT RESPONSE, AND MODERN USE CONTROL FEATURES.

ON 31 DECEMBER 1986, THE U.S. NUCLEAR WARHEAD INVENTORY CONSISTED OF Deleted 27 DIFFERENT WARHEAD TYPES. THE YIELD OF THIS TOTAL STOCKPILE IS MT. THE NUCLEAR WARHEAD INVENTORY Deleted DURING THE PRECEDING YEAR. THE LARGEST WARHEAD IN THE INVENTORY, OF WHICH THERE ARE Deleted THE SMALLEST YIELD WEAPON IN THE INVENTORY, OF WHICH WE HAVE Deleted. THE OLDEST WARHEAD TYPE IS THE W31Y1, NIKE HERCULES, OF WHICH Deleted EXIST WITH AN AVERAGE AGE OF 27.91 YEARS. THE AVERAGE WARHEAD AGE ON 31 DECEMBER 1986 WAS 12.79 YEARS; ONE YEAR EARLIER THE AVERAGE AGE WAS 12.71 YEARS.

(U) NUCLEAR WEAPON MODERNIZATION HAS OCCURRED PRIMARILY WHEN AN EXISTING WEAPON SYSTEM BECAME VIEWED AS NO LONGER POSING A CREDIBLE DETERRENT IN THE FACE OF SOVIET MEASURES WHICH HAVE ADVERSELY AFFECTED WEAPON EFFECTIVENESS. SUCH SOVIET MEASURES INCLUDE STEPS WHICH THREATEN DELIVERY SYSTEM SURVIVABILITY AND PENETRABILITY OF DEFENSES AND/OR STEPS WHICH REDUCE WEAPON EFFECTIVENESS, SUCH AS HARDENING OR MOBILITY OF INTENDED TARGETS. THE REPLACEMENT WEAPON SYSTEM GENERALLY REQUIRES A NEW WARHEAD TO BE COMPATIBLE WITH THE ENVIRONMENTS WHICH THE NEW WEAPON SYSTEM WILL IMPOSE ON THE WARHEAD. THE NEW WEAPON MAY HAVE A SMALLER OR LARGER YIELD THAN THE WEAPON IT REPLACES, DEPENDING, FOR EXAMPLE, ON WHETHER HIGHER ACCURACIES JUSTIFY A LOWER YIELD OR WHETHER INCREASES IN TARGET HARDNESS REQUIRE HIGHER YIELDS EVEN WITH INCREASED ACCURACY. WHENEVER A NEW WEAPON IS DESIGNED, IT INCORPORATES THE STATE-OF-THE-ART IN NUCLEAR WEAPON SAFETY AND SECURITY FEATURES.

(U) THE NUCLEAR WEAPON MODERNIZATION PROCESS IS, THEREFORE, NOT SUCH THAT THE OLDEST WEAPON IS THE NEXT TO BE MODERNIZED. WITHIN THE LIMITED RESOURCES AVAILABLE FOR NUCLEAR WEAPON SYSTEMS MODERNIZATION, PRIORITY IN MODERNIZATION GOES TO THE SYSTEM WHOSE REDUCED EFFECTIVENESS AS A DETERRENT IS VIEWED AS BEING MOST IMPORTANT POLTICALLY AND MILITARILY. AS A RESULT, SOME WEAPONS HAVE BECOME SO OLD THAT THEIR SAFETY AND SECURITY FEATURES, WHILE ADEQUATE TO MEET NUCLEAR SAFETY STANDARDS, DO NOT MEET MODERN NUCLEAR SAFETY DESIGN CRITERIA. THIS HAS LED TO STOCKPILE IMPROVEMENT PROGRAM (SIP) UPGRADES OF PARTICULAR WEAPON FEATURES OF SOME WEAPONS TO REDRESS THESE DEFICIENCIES.

(U) STOCKPILE IMPROVEMENT PROGRAM. THE JOINT DoD/DOE STOCKPILE IMPROVEMENT PROGRAM (SIP) WAS INITIATED FORMALLY BY THE MILITARY LIAISON COMMITTEE IN 1979, WITH THE GOAL OF IDENTIFYING THE NUCLEAR WEAPONS IN THE STOCKPILE THAT NEEDED TO BE MODERNIZED, THOSE THAT NEEDED TO BE RETIRED OR REPLACED, AND THOSE WHICH REQUIRED NO ACTION. EACH YEAR A REVIEW IS ACCOMPLISHED WITH THE OBJECTIVE OF EXAMINING EACH DEPLOYED WEAPON, ITS OPERATING ENVIRONMENT, SERVICE RECOMMENDATIONS, RESULTS OF STUDIES, PRESENT SIP EFFORTS, AND/OR PLANNED RETIREMENT/REPLACEMENT PROGRAMS.

THE MAJOR EMPHASIS IN 1986 CONCERNED THE TACTICAL BOMB STOCKPILE INITIATIVE (TBSI); THE W69, SRAM A; AND THE W50, PERSHING I. IN THE TBSI, Deleted B61 WARHEADS WILL BE UPGRADED

Deleted COMPLETION OF THE W69 RETIREMENT WILL BE REFLECTING A REPLACEMENT BY THE SRAM II, WHICH INCORPORATES A MODERN WARHEAD WITH MODERN SAFETY AND SECURITY FEATURES. FOR THE PERSHING I, OPTIONS Delete

ARE BEING CONSIDERED, WITH THE STUDY SCHEDULED FOR COMPLETION IN JUNE 1987.

(U) IN THOSE CASES WHERE OUR REQUIREMENTS CAN BEST BE MET BY THE DEVELOPMENT OF NEW SYSTEMS AND WARHEADS, THE FOLLOWING SYSTEMS ARE UNDER DEVELOPMENT, IN PRODUCTION, OR HAVE BEEN DEPLOYED.

ARMY

W79 (8-INCH) AND W82 (155MM) ARTILLERY FIRED ATOMIC PROJECTILES (AFAP). THE W79, MODERNIZED 8-INCH AFAP, COMPLETED PRODUCTION IN FY86. THIS NEW WEAPON PROVIDES REDUCED REACTION TIME AND INCREASED RANGE *Deleted* INCREASED RELIABILITY, AND MODERN SAFETY AND SECURITY.

Deleted

IN ACCORDANCE WITH THE PROVISIONS OF THE FY 1985 DoD AUTHORIZATION ACT, THE PRODUCTION PROGRAM FOR THE MODERNIZED *Deleted* W82 155MM AFAP HAS BEGUN. THE W82 HAS ENTERED THE PRODUCTION ENGINEERING PHASE AND FIELDING IS PLANNED FOR *Deleted* THIS PROGRAM IS A NECESSARY FIRST STEP TOWARD ACHIEVEMENT OF SACEUR'S LONG-TERM OBJECTIVE OF

Deleted

FULFILLING PART OF THE MODERNIZATION REQUIREMENT ASSOCIATED WITH THE 1983 NATO DECISION AT MONTEBELLO TO REDUCE THE EUROPEAN STOCKPILE. THE CURRENT W82 PROGRAM WILL PROVIDE REPLACEMENTS FOR *Deleted* OF THE APPROXIMATELY *Deleted* AGING 23-YEAR-OLD W48s AND WILL INCLUDE MODERN SAFETY, SECURITY, AND CONTROL DEVICES ALONG WITH PROVIDING INCREASED RELIABILITY, RANGE, AND ACCURACY. THE 925 MODERNIZED PROJECTILES AUTHORIZED BY THE FY 1985 DoD AUTHORIZATION ACT WILL

NOT MEET NATO OR WORLDWIDE CINC REQUIREMENTS. THEREFORE, OLDER WEAPON SYSTEMS (W33 AND W48) WILL BE RETAINED.

(U) PERSHING II DEPLOYMENT. ALL 108 PERSHING II HAVE BEEN DEPLOYED TO U.S. FORCES IN THE FEDERAL REPUBLIC OF GERMANY IN ACCORDANCE WITH NATO'S 1979 DUAL-TRACK DECISION. PRODUCTION OF THE W85 WARHEAD FOR THIS SYSTEM HAS BEEN COMPLETED.

FOLLOW-ON TO LANCE. SACEUR HAS STATED *Deleted* *Deleted* FOLLOW-ON TO THE LANCE MISSILE SYSTEM WITH INCREASED RANGE AND ACCURACY, AND IMPROVED OPERATING CHARACTERISTICS. *Deleted* *Deleted* HAVE STATED SIMILAR REQUIREMENTS FOR A REPLACEMENT FOR THE CURRENT LANCE.

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IN ORDER TO MEET THE NEEDS STATED BY THESE STUDIES ARE NECESSARY FOR MAKING A DECISION (BASED ON OPERATIONAL EFFECTIVENESS, FEASIBILITY, AND COST), ON THE BEST SYSTEM TO REPLACE THE LANCE. THE ARMY HAS BEGUN STUDYING CANDIDATES FOR THE FOLLOW-ON TO LANCE AND PLANS TO INITIATE A FORMAL PHASE 2 NUCLEAR WARHEAD FEASIBILITY STUDY WITH THE DEPARTMENT OF ENERGY THIS YEAR. ARMY TACMS IS GENERALLY CONSIDERED TO BE A STRONG CANDIDATE FOR THE LANCE FOLLOW-ON FOR AT LEAST THREE REASONS. FIRST, IT WOULD ALLOW THE ARMY TO TAKE ADVANTAGE OF DEVELOPMENT WORK ALREADY INVESTED IN CONVENTIONAL ATACMS, AS WELL AS THE FORCE STRUCTURE PLANNED FOR IT. MODIFICATIONS TO THE MLRS LAUNCHER AND PROCUREMENT OF THE NECESSARY MISSILES TO MAKE ATACMS DUAL-CAPABLE WOULD COST SIGNIFICANTLY LESS THAN DEVELOPING AND PROCURING THE SAME NUMBER OF AN ENTIRELY NEW, NUCLEAR-ONLY SYSTEM. SECOND, A DUAL-CAPABLE ATACMS WOULD BE MORE SURVIVABLE THAN A FORCE OF NUCLEAR-ONLY

SYSTEMS, SINCE ALL MLRS LAUNCHERS WILL BE CAPABLE OF FIRING ATACMS. THIRD, A DUAL-CAPABLE ATACMS WOULD BE MORE ATTRACTIVE TO ALLIES, BECAUSE THEY PLAN TO FIELD, AND IN SOME CASES CO-PRODUCE, MLRS. THEREFORE WE WOULD LIKE TO INCLUDE ARMY TACMS AS ONE OF THE CANDIDATES IN THE PHASE 2 WARHEAD FEASIBILITY STUDY. HOWEVER, A CONGRESSIONAL RESTRICTION (INITIALLY THE KENNEDY-NUNN AMENDMENT TO THE 1984 APPROPRIATIONS ACT BUT CARRIED FORWARD EACH YEAR) HAS BEEN INTERPRETED AS PREVENTING EVEN THE STUDY OF NUCLEAR CAPABILITY FOR THE ARMY TACTICAL MISSILE SYSTEM (ARMY TACMS). WE ASK THAT CONGRESS LIFT THE RESTRICTION ON STUDYING A NUCLEAR ARMY TACMS IN ORDER THAT IT CAN BE STUDIED WITH OTHER CANDIDATES AS A REPLACEMENT FOR LANCE. WE EXPECT TO FULLY JUSTIFY TO CONGRESS ANY REQUEST FOR A LANCE FOLLOW-ON SYSTEM.

NAVY

TLAM/N. THE TOMAHAWK NUCLEAR LAND ATTACK CRUISE MISSILE, OR TLAM/N, GREATLY ENHANCES THE NAVY'S DETERRENT POSTURE BY DISTRIBUTING NAVY RETALIATORY STRIKING POWER ACROSS A LARGE NUMBER OF NAVAL PLATFORMS. THIS INCREASES THE NUMBER OF WARSAW PACT TARGETS THAT ARE PUT AT RISK AND GREATLY COMPLICATES SOVIET DEFENSIVE EFFORTS. TOMAHAWK COMPLEMENTS THE POWER OF THE CARRIER AIR WING AND MULTIPLIES THE EFFECTIVENESS OF THE FORCE AT SEA. TLAM/N WILL ALSO CONTRIBUTE TO THE NCA'S ABILITY TO DETER STRATEGIC CONFLICT AND WILL PROVIDE ADDITIONAL SURVIVABLE ASSETS FOR THE NUCLEAR RESERVE FORCE. TLAM/N REACHED INITIAL OPERATIONAL CAPABILITY (IOC) IN JUNE, 1984, AND WILL BE INSTALLED ON THE FOLLOWING CLASSES OF SHIPS: SSN-637 STURGEON AND SSN-688 LOS ANGELES CLASS ATTACK SUBMARINES: DD-963 SPRUANCE AND DDG-51 ARLEIGH BURKE CLASS DESTROYERS; CGN-9 LONG BEACH, CGN-38 VIRGINIA, AND CG-47 TICONDEROGA CLASS CRUISERS; AND BB-61 IOWA CLASS BATTLESHIPS. AT PRESENT OVER THIRTY NAVY SHIPS AND

SUBMARINES ARE CERTIFIED TO CARRY TLAM/N. WITHIN THE NEXT FIVE YEARS, Deleted TLAM/N MISSILES WILL BE DEPLOYED IN Deleted SHIPS AND SUBMARINES.

(U) SEA LANCE. A NUCLEAR VARIANT OF THE SEA LANCE SUBMARINE-LAUNCHED ASW STAND-OFF WEAPON IS REQUIRED TO REPLACE SUBROC, A 23-YEAR-OLD SYSTEM WHICH IS INCOMPATIBLE WITH OUR MODERN FIRE CONTROL SYSTEMS.

A DoD-DIRECTED SPECIAL STUDY OF THE SEA LANCE (NUCLEAR) IN THE SUMMER OF 1986 REAFFIRMED THE NEED FOR THIS WEAPON. TO ENSURE A LONG-RANGE HIGH PROBABILITY OF KILL AGAINST THE MODERN SOVIET SUBMARINES, THE NAVY IS CURRENTLY VALIDATING YIELD AND INVENTORY REQUIREMENTS FOR THE NUCLEAR VARIANT. Deleted

Deleted

NUCLEAR DEPTH/STRIKE BOMB. A NEW AIR-DELIVERED NUCLEAR DEPTH BOMB WITH STRIKE CAPABILITY IS NEEDED FOR OUR ASW AIRCRAFT FORCE. THE NAVY AND THE DOE ARE IN THE FINAL STAGES OF A PHASE 2A STUDY TO EXAMINE WARHEAD CANDIDATES, INCLUDING A VARIANT OF AN EXISTING B61. THIS NUCLEAR DEPTH/STRIKE BOMB. WITH MODERN SAFETY AND SECURITY FEATURES, IS PLANNED TO REPLACE THE 28-YEAR-OLD B57 TACTICAL STRIKE BOMBS AND B57 DEPTH BOMBS WHICH WILL BE RETIRED Deleted THIS COMMONALITY WILL ALLOW SMALLER AIRCRAFT CARRIER BOMB LOADOUTS THAN WOULD OTHERWISE BE POSSIBLE WITH SEPARATE TACTICAL STRIKE AND DEPTH BOMBS, THEREBY REDUCING OVERALL STOCKPILE NUMBERS OF FLEET STRIKE AND DEPTH BOMBS. THE NUCLEAR DEPTH/STRIKE BOMB HAS AN IOC IN THE Deleted

Deleted

TRIDENT II (D-5) W88. THE TRIDENT II (D-5) MISSILE IS NOW IN ITS FOURTH YEAR OF FULL-SCALE ENGINEERING DEVELOPMENT, AND COMPLETED ITS FIRST FLIGHT TEST IN JANUARY 1987. DOE IS

DEVELOPING THE W88 Deleted WARHEAD FOR THIS MISSILE.

Deleted

THE D-5 WILL PROVIDE OUR SURVIVABLE, SEA-BASED STRATEGIC FORCE WITH GREATLY IMPROVED HARD TARGET KILL DETERRENT CAPABILITY. D-5 WILL FIRST BECOME OPERATIONAL WHEN IT GOES TO SEA IN THE NINTH TRIDENT SUBMARINE FROM ITS HOME BASE AT KINGS BAY, GEORGIA. THE NINTH AND SUBSEQUENT NEW CONSTRUCTION TRIDENT SSBNs WILL BE D-5 EQUIPPED.

(U) THE ORIGINAL EIGHT TRIDENTS WILL BE BACKFITTED WITH THE D-5 SYSTEMS DURING REGULARLY SCHEDULED OVERHAULS. THE SUBMARINE BASE AT BANGOR, WASHINGTON, WILL BE EQUIPPED TO SUPPORT D-5 BY 1994 AS WE PROCEED TOWARD AN ALL D-5 TRIDENT FORCE.

AIR FORCE

(U) IN THE AREA OF INTERCONTINENTAL BALLISTIC MISSILES, THE 19 DECEMBER 1986 PRESIDENTIAL DECISION STATED THAT WE SHOULD "PROCEED WITH FULL-SCALE DEVELOPMENT OF THE SMALL ICBM AND BEGIN DEVELOPMENT OF A MOBILE RAIL GARRISON BASING MODE FOR PEACEKEEPER." IN ADDITION, THE PRESIDENT STATED THE "INITIAL OPERATING CAPABILITY FOR THE SMALL ICBM WOULD BE ACHIEVED IN 1992." BEFORE ANY FUNDS FROM THE DEPARTMENT OF ENERGY'S BUDGET CAN BE SPENT ON WARHEADS FOR THE 2ND FIFTY PEACEKEEPERS, CONGRESSIONAL RESTRICTIONS IMPOSED IN FY 1985 MUST BE LIFTED.

(U) THE SMALL ICBM IS CURRENTLY UNDERGOING A PHASE 2A STUDY WHICH IDENTIFIED THE BASELINE WARHEAD DESIGN AS A MODIFIED VERSION OF THE PEACEKEEPER WARHEAD, THE W87. THE SICBM WARHEAD, AS APPROPRIATE FOR A MOBILE SYSTEM, WILL INCORPORATE NECESSARY USE CONTROL FEATURES.

(U) WE ARE CONTINUING OUR CONCEPT STUDIES TO ENSURE OUR ABILITY TO SATISFY CHANGING DEFENSE NEEDS. THE AIR FORCE, IN CONJUNCTION WITH THE DOE, PERFORMED STUDIES TO IDENTIFY NUCLEAR WEAPON CONCEPTS TO HOLD HARDENED/UNDERGROUND AND DEEPLY BURIED TARGETS AT RISK BY OUR STRATEGIC FORCES. THESE STUDIES IDENTIFIED EARTH PENETRATING WEAPONS COUPLED WITH HIGH ACCURACY DELIVERY SYSTEMS (AIRCRAFT AND ICBM) AS BEING EFFECTIVE AGAINST THESE TARGETS. ADDITIONAL STUDIES WILL BE PERFORMED TO IDENTIFY THE OPERATIONAL TRADEOFFS, COSTS, AND DESIGN SPECIFICATIONS OF EARTH PENETRATING WEAPON SYSTEMS.

THE B53 BOMB, WHICH WAS IN THE INACTIVE RESERVE, IS BEING RETURNED TO OPERATIONAL STATUS

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(U) I WOULD LIKE TO CLOSE BY BRIEFLY ADDRESSING NUCLEAR TESTING. IN THE PAST FEW YEARS THE NEED FOR NUCLEAR TESTING HAS RECEIVED MUCH ATTENTION. WE HAVE PROVIDED THE CONGRESS WITH REAMS OF INFORMATION AND HOURS OF TESTIMONY AS TO THE ESSENTIAL NATURE OF NUCLEAR WEAPON TESTING AND ITS PLACE IN OUR NATIONAL SECURITY POSTURE. I WILL NOT REPEAT OR EVEN SUMMARIZE THAT PRIOR DICTA. HOWEVER--FEARING THAT THE HEART OF THE ISSUE MAY HAVE BEEN OBFUSCATED BY THE FUSILLADE OF WORDS--LET ME RESTATE THE OBVIOUS. AS LONG AS WE MUST CONTINUE TO RELY ON NUCLEAR WEAPONS TO SECURE THIS NATION AND MAINTAIN THE PEACE, ATTEMPTS TO BAN NUCLEAR TESTING ARE MORE THAN FOOLISH--THEY ARE DANGEROUS IN THE EXTREME. IN ADDITION TO THE NEED FOR NUCLEAR TESTING DURING THE DEVELOPMENT AND CERTIFICATION OF OUR NUCLEAR WEAPONS AND VERIFICATION OF RELIABILITY, THE BROADER CONTRIBUTION OF UNDERGROUND NUCLEAR EFFECTS TEST TO OUR DETERRENT POSTURE IS CRITICAL.

(U) UNDERGROUND NUCLEAR WEAPONS EFFECTS TESTS ARE OF DIRECT NATIONAL IMPORTANCE IN THAT THEY DIRECTLY SUPPORT THE DEVELOPMENT AND CERTIFICATION OF THE NUCLEAR HARDNESS OF CRITICAL WEAPON SYSTEMS, INCLUDING TACTICAL WEAPON SYSTEMS; COMMAND, CONTROL, COMMUNICATIONS AND INTELLIGENCE SYSTEMS, AS WELL AS STRATEGIC NUCLEAR SYSTEMS SUCH AS THE PEACEKEEPER AND TRIDENT II. THESE TESTS ARE HIGHLY COMPLEX, AND OFTEN SEVERAL TESTS ARE NEEDED IN CONJUNCTION WITH EXTENSIVE ABOVE GROUND TESTS TO VALIDATE A GIVEN SYSTEM FOR OPERATIONAL USE OVER THE TOTAL NUCLEAR ENVIRONMENT. THE EFFECTIVENESS AND CREDIBILITY OF THESE SYSTEMS HINGE DIRECTLY ON THE SUCCESS OF THESE DEVELOPMENT AND CERTIFICATION TESTS. THE DoD AND DOE LABORATORIES DERIVE INVALUABLE FUNDAMENTAL NUCLEAR EFFECTS RESEARCH DATA FOR USE IN THE DEVELOPMENT OF THE TECHNOLOGY BASE. THE DEVELOPMENT OF MISSILE BASING SYSTEMS, INCLUDING THE AIR FORCE PEACEKEEPER AND SMALL MISSILE PROGRAMS, ARE SUPPORTED BY TESTS WHICH ARE DEFINED AND CONDUCTED TO PROVIDE NUCLEAR BLAST AND SHOCK ENVIRONMENT NOT SUITABLE TO INVESTIGATION BY SIMULATION OR CALCULATION. RECENT UNDERGROUND TEST PROGRAM EMPHASIS HAS BEEN ON VULNERABILITY AND HARDNESS OF THE PEACEKEEPER MISSILE AND MK-21 REENTRY SYSTEM, THE TRIDENT II D-5 MISSILE AND MK-5 REENTRY SYSTEM, AND THEIR COMPONENTS AND SUBSYSTEMS. TESTS CONDUCTED IN DIRECT SUPPORT OF THE TRIDENT II AND SMALL ICBM ENGINEERING DEVELOPMENT MILESTONES WILL RECEIVE SPECIAL EMPHASIS IN THE FUTURE EVENTS. UNDERGROUND TESTS ARE ALSO BEING USED TO SUPPORT THE STRATEGIC DEFENSE INITIATIVE PROGRAM IN CONDUCTING X-RAY LASER LETHALITY AND SURVIVABILITY EXPERIMENTS AND EXPERIMENTS ASSOCIATED WITH THE ARMY'S ERIS AND HEDI BALLISTIC MISSILE DEFENSE SYSTEMS.

(U) IN SUMMARY, LET ME MAKE THE FOLLOWING POINTS:

- THE CORNERSTONE OF OUR DETERRENT POSTURE IS, AND WILL BE FOR THE FORESEEABLE FUTURE, OUR NUCLEAR WEAPONS CAPABILITY.

- WE MUST MAINTAIN A VIGOROUS RD&T EFFORT IN THE TRADITIONAL PROGRAM, WHILE SUPPORTING DOE SDI-RELATED ACTIVITIES CONSISTENT WITH DoD MILESTONES.

- FISCAL RESPONSIBILITY AND COST DISCIPLINE MUST BE FUNDAMENTAL TO THE NUCLEAR WARHEAD PROCUREMENT PROCESS.

- MODERNIZATION OF THE STOCKPILE, INCLUDING MODERN SAFETY AND SECURITY, IS ONLY ONE-THIRD COMPLETE AND MUST BE CONTINUED.

- AN ORDERLY SYSTEM FOR THE NUCLEAR WEAPONS DEVELOPMENT PROCESS PRESENTLY EXISTS, AND SHOULD BE ALLOWED TO FUNCTION AS INTENDED.

- NUCLEAR TESTING IS AN INTEGRAL AND ESSENTIAL PART OF OUR DETERRENT POSTURE.

(U) THIS CONCLUDES MY FORMAL TESTIMONY. I WOULD BE HAPPY TO ANSWER QUESTIONS.

DOE ACTIVITIES RELATED TO SDI

Dr. **Barker**. They have just been talking about the 5 percent of the DOE budget in 1988 that is directly related to SDI support. Now though, as General Abrahamson said, the laboratories do more for SDI than that, do more than what is funded directly by the Department of Energy.

We really found ourselves in a very tight budget situation for fiscal year 1988. In fact, at the 11th hour, just before the budget went to the President, the Secretary of Defense moved $100 million from the Defense portion of the 050 account to the defense programs Department of Energy portion of the 050 account, because we felt that the budget, without that transfer, without that movement, would either do drastic damage to the traditional nuclear weapons program or not allow the Department of Energy to adequately support the Strategic Defense Initiative.

That is the seriousness with which we saw the level that actually came to you from the President as far as the Department of Energy support is concerned. We have just spent a fair amount of time talking about the critical nature of the Department of Energy's portion to SDI. Let me talk a little bit now about the traditional weapons program.

Of course, the ultimate hope of SDI is that it will enable us to abandon offensive deterrence as a national strategy. That is a fair ways off, I think—even General Abrahamson would agree—before we can abandon that.

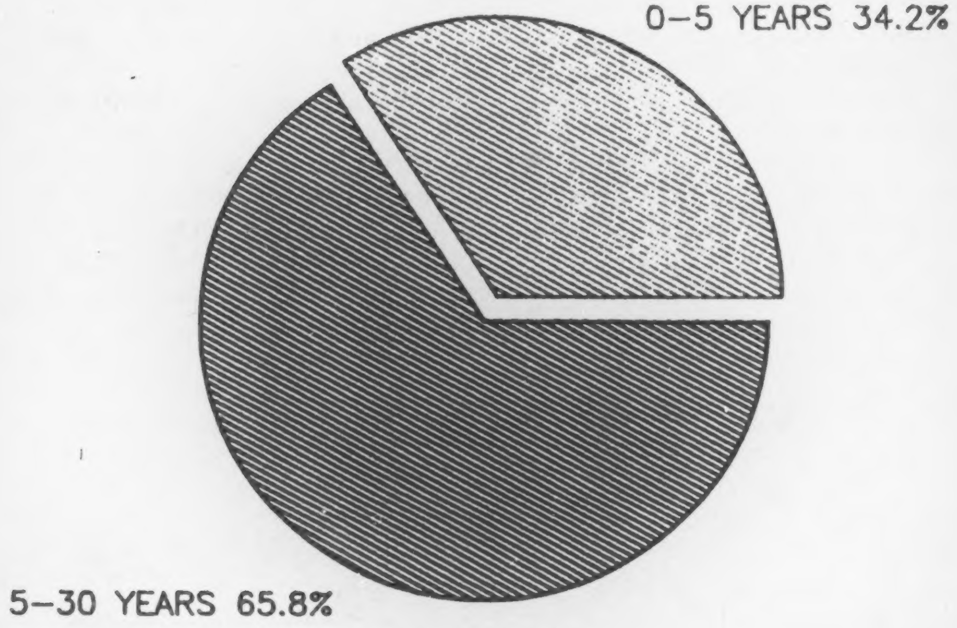
Senator **Johnston**. But we won't abolish the labs, at least until milestone 2. [Laughter.]

Dr. **Barker**. What I wanted to remind the committee is the magnitude of this job that is ahead of us. The National Resources Defense Council apparently has just published for the world, accurately or inaccurately, and for better or worse, a story of what the Department of Energy's nuclear weapon complex can do for us and what the nuclear weapon stockpile is.

MAJOR ISSUES

- THE CORNERSTONE OF OUR DETERRENT POSTURE IS, AND WILL BE FOR THE FORESEEABLE FUTURE, OUR NUCLEAR WEAPONS CAPABILITY.
- FISCAL RESPONSIBILITY AND COST DISCIPLINE IS FUNDAMENTAL TO THE NUCLEAR WARHEAD PROCUREMENT PROCESS.
- WE MUST MAINTAIN A VIGOROUS RD&T EFFORT IN THE TRADITIONAL DOE PROGRAM, WHILE SUPPORTING DOE SDI-RELATED ACTIVITIES CONSISTENT WITH DOD MILESTONES.
- MODERNIZATION OF THE STOCKPILE, INCLUDING MODERN SAFETY AND SECURITY, IS ONLY ONE-THIRD COMPLETE AND MUST BE CONTINUED.
- NUCLEAR TESTING IS AN INTEGRAL AND ESSENTIAL PART OF OUR DETERRENT POSTURE.

NUCLEAR WARHEAD STOCKPILE AGE
TOTAL STOCKPILE – FY 87



STOCKPILE MODERNIZATION

Dr. BARKER. In the last 5 years, this administration, with the full support of the Congress, has been able to modernize one-third of our nuclear stockpile. But that means two-thirds of it has yet to be modernized, and let me touch on what that means.

I am going to touch on four different aspects of nuclear weapons that often don't get much attention. First, is use control features. A very important aspect of modern nuclear weapon designs is that an unauthorized person cannot derive a useful yield from them. The modern use control features are the things we call category D and category F permissive action links [PAL's]. In 1987, about [deleted] percent of today's stockpile has those modern control features in it. The kinds of weapons that should have these features are the kinds of weapons that are potentially accessible by terrorists. And so we do not plan to put these things on strategic systems, particularly silo-based and submarine-based systems.

But even so, about [deleted] percent of the stockpile should have these modern use control features, rather than the present [deleted] percent. That is part of the big job ahead of us.

INSENSITIVE HIGH EXPLOSIVES

To me, maybe the most significant issue is insensitive high explosives. Ten years ago, the laboratories invented insensitive high explosives, something which literally can preclude plutonium dispersal in the most violent of accident situations. Today, [deleted] percent of the stockpile has insensitive high explosives in it, and about [deleted] percent can and should have insensitive high explosives in it.

We are limited in two ways. Some technologies, some weapon delivery systems, such as [deleted] cannot produce a nuclear yield and use insensitive high explosives. Also, there is no need for certain silo-based systems to have it in them. A weight penalty is significant. But we have got a long way to go. [Deleted] percent is done; we have got to get to the [deleted] percent point. We really require a test program to incorporate that kind of material into a stockpiled weapon.

Senator JOHNSTON. I strongly support you on that.

Dr. BARKER. I am pleased, because I am going to tell you what has been happening to us because of the kind of budget stringencies that we have been faced with.

NONVIOLENT DISABLEMENT CAPABILITY

Nonviolent disablement is also a very important part of nuclear weapon design. We want to be sure that a commander can destroy a weapon before it's overrun and taken; that he has confidence that he can do that. We want him to be able to destroy the weapon without scattering plutonium all over the landscape.

Senator JOHNSTON. How can you do that?

Dr. BARKER. There are ways to—I don't want to get into it in detail here because the Department of Energy puts a very limited stricture on need to know as far as the details are concerned. I am sure they would be happy to discuss it with you personally. But it is literally possible to incorporate within the design a way to make it impossible for someone to derive a yield from a nuclear weapon without basically going back to the manufacuring process.

We can incorporate those kinds of features in nuclear weapon design.

Senator JOHNSTON. I would like that briefing sometime.

Dr. BARKER. I cannot speak for Admiral Foley, but I would imagine he would be happy to do it at any time you are so interested.

So it is at the [deleted] percent level right now.

ACCIDENT SAFE ELECTRICAL RESPONSE

Dr. BARKER. The other big issue is predictable accident safe electrical response. This is a technology that Sandia has developed. Again, it is a 10-year-old technology which allows us to estimate how a system will respond electrically in an accident, what kind of electrical signals will be produced and can we absolutely preclude certain kinds of signals from being produced that are associated with normal nuclear weapons deployment.

They have developed this technology. We have got into about 40 percent of the weapons in today's stockpile as a result of this modernization process, and we have still got a long ways to go.

IMPACT OF FUNDING REDUCTIONS

In general, we don't have the money. We have never had the money to just go back in and retrofit the stockpile to put all these features in. And in some cases, it is not a simple job to totally redesign to incorporate these features.

So as the stockpile is modernized, we asked the Department of Energy to incorporate all of these features into those weapon designs.

Every time there is a cutback, we end up delaying and keeping for a longer period of time the systems that don't have insensitive high explosives, that don't have modern accident safe electronics, and systems that don't have command destruction.

As a result of last year's cuts in the President's budget, we have had to delay for 2 years the retirement of the B–43. We have had to delay for 2 years the retirement of the B–57 bomb. That means that in fiscal year 1992, we are going to have [deleted] of those weapons in our stockpile instead of the [deleted] that we would have had had the President's budget been approved.

When the DOE budget gets cut, Admiral Foley comes to me and says, "We can't meet all your requirements. What are your priorities?" We sit down and agonize over that list. And, in general, what has happened is the strategic system modernization has taken a priority, and the things that get pushed off are these things that look like little steps, but as far as I am concerned, are some of the most critical things that we can do for the stockpile, making it safer and making it more secure.

And we are right now, even with the President's budget, marginal. I make the point that the Secretary of Defense felt strongly enough to take $100 million out of his side of the line and transfer it over to DOE before the Congress ever saw the budget request. That helped. Fine. We think the DOE is being honed in order to meet the totality of requirements.

I just hope that you and your colleagues would better appreciate the fact that two-thirds of the stockpile we have got out there, which is a very critical fraction of the nuclear deterrent we all depend upon, is aging and can be improved in safety and security. And these are the tough choices we are facing.

Senator JOHNSTON. I am very worried about that. I know what can happen when those B–52's have a fire. And it is amazing to me that we have not had a serious incident. And I have got a SAC base in my hometown.

Dr. BARKER. We have been lucky.

I am not going to feel comfortable until every weapon on a B–52 has insensitive high explosives in it. And that's the reason why the SRAM II is as important as it is. Because until we can replace the SRAM A with SRAM II with those B–52's, we are going to have weapons on them with old-fashioned conventional explosives. And I hear that the Congress is taking a dim view on SRAM II.

If SRAM II gets the later slip in fiscal year 1988, it is just a year-for-year slip in terms of having SRAM II on the system. It is just a critical element of B–52 credibility. It could mean the difference between insensitive and noninsensitive explosives.

DOE BUDGET

I appreciate the opportunity to make some short remarks. But the DOE budget is very, very critical to the fundamental thing we all depend upon: nuclear deterrence. Every dollar cut delays, drags out, and we have to live with things that I think are very untested and do need to be addressed.

Senator JOHNSTON. I think you make a very strong case, Dr. Barker.

Mr. FOLEY. I know that Dr. Barker has to leave soon and the General does too, but I held off a few specifics until they finished off in the proposal in order to meet a prospective vote of your $500 to $600 million. We are talking about delaying the SRAM II [deleted] perhaps canceling the small ICBM; canceling maybe the W–82, and that will never sell. You know that. But these are the proposals coming in. But we are canceling [deleted] tests. [Deleted.] These are the ways we are trying to aggregate to come up somehow with $500 or $600 million. And when we go through all this, we come out with saying, "I can't do this. It doesn't make any sense to do that." So I come back and say, "You have got to bump that back up."

EFFECTIVENESS OF SPACE-BASED INTERCEPTOR

Senator JOHNSTON. General, when you said that our report that 16-percent effectiveness was not correct, and you said 30 percent, really your disagreement is that rather than taking the totality of their warheads, [deleted] you took, in effect, a first wave, and that it is 30 percent of the first wave, but it might be 16 percent of the total.

General ABRAHAMSON. You know, I did not calculate it in that particular way. But the important part is when you are indeed dealing with these scenario-dependent kinds of activities, the important one is how do they fight and what are you trying to preclude. And that may well be the only sensible way to do that.

Senator JOHNSTON. Well, Lockheed told us there would be [deleted] and our 16-percent figure was based on killing 400 Soviet warheads with [deleted] and 1,000 Soviet warheads with SBKKV, which is [deleted] which is 15 percent. We rounded it to 16 percent.

Isn't that, in fact, what Lockheed was given as a goal?

General ABRAHAMSON. Lockheed is not building the space-based interceptor nor any of those particular ones. They are doing a set of these kinds of studies. And, frankly, I don't know what they were given. If you want to go right down to this 16-percent issue, I will go back and give you, for the record, an accurate kind of a layout of that particular point.

PREMATURE DEPLOYMENT

There is something else, however, and I think it is important to illustrate.

I know you are concerned about, and I will assume that your concern is about premature deployment——

Senator JOHNSTON. That's right.

General ABRAHAMSON. But in addition to that, you should not have the impression that I don't and other people don't understand that there's a very careful and important relationship between the first stage of a deployment and how long that takes, and when you then could begin to roll in some of the second phase and the advanced technology systems.

When we have talked and argued and dealt with this question of the first phase, it is often dealt with like, that's it. It is absolutely critical, in my judgment, that you have your technology coming along at such a pace and in such a way that a second phase could be deployed at an appropriate time. And I don't know if it's 3 or 4 or 5 years. It depends on your understanding of just exactly how it is that the Soviets might be able to respond.

So please don't get the impression that I'm saying that, you know, we can go with the first phase and ignore the relationship with the advanced technology and with the research.

Senator JOHNSTON. The American Physical Society said that it would be 10 years or more before you would know enough to make a development decision on directed energy weapons. Do you disagree with that?

General ABRAHAMSON. Yes; I do.

DIRECTED ENERGY TECHNOLOGY MILESTONES

Senator JOHNSTON. What timeframe do you see for milestone 2 on directed energy?

General ABRAHAMSON. Well, it depends an awful lot on how much money we have available in the whole program.

Senator JOHNSTON. Well, actually hasn't there been in the last year or two a downphasing of directed energy weapons financing while you upphased the KKV?

General ABRAHAMSON. That is not my perspective. I think we can put that up.

Here really are the totals, and you can see that we are still spending more money—not as much as I would like—on directed energy weapons than I was on the kinetic energy weapon.

Now, I will give you what my perspective is on this so that I think this is the accurate way to look at it.

In the kinetic energy weapons there are a series of fairly mature technologies that have been out there—they have been there for a long time, and there is really only one program in each of these areas. For example, terminal interceptor. There is only the HEDI Program. We have technology that is flowing into that, but there is only that one program.

Senator JOHNSTON. Well, getting back to this, I know where those trends are. But compared to what the plan was a year or two ago, hasn't that been changed?

General ABRAHAMSON. What the plan was a year or two ago was in the directed energy areas that we were going to try to take forward because there was very high risk, a whole series of directed energy concepts. The free electron laser was one of those. We were also going to take forward a lot of chemical laser work.

In addition to that, we were going to take forward what is called the Excimer laser, and it was because of the risk in all of those areas. What I finally had to do as I saw these cuts, and as I saw that, in fact, we were making much more progress in certain of the areas, was to make choices.

Senator JOHNSTON. Well, all I am saying is that the choice has been down on directed energy and up on space-based KKV as a relative percentage, as an area of emphasis.

General ABRAHAMSON. In terms of the total amount of budget that was hoped for, and what came out, yes, that is true. But in terms of the space-based interceptor, that was a program that was always there, always hoped to be able to go forward at a particular rate. And we have had to cut that. But, no, we haven't cut it as much. That's true.

Senator JOHNSTON. In the President's budget request for fiscal year 1987, as presented to us January 28——

General ABRAHAMSON. Last year. We had hoped for a major increase in directed energy.

Senator JOHNSTON. And directed energy was up $1.530 million and it is a little over one-half that. It is very clear to me that it has absorbed a higher percentage of cuts in space-based activity.

General ABRAHAMSON. Yes, sir; it has. That is correct.

Senator JOHNSTON. There has been a difference.

KINETIC ENERGY WEAPONS

General ABRAHAMSON. It's not the space-based KKV though, and that is what you have to recognize. Kenetic energy weapons is not all space-based KKV. There are several concepts: the HEDI, the ERIS. It has some of the theater kinds of weapons. It has a theater program as well, and it has the space-based interceptor. It has all of those.

Senator JOHNSTON. General, there is a raging debate in the country, in case you haven't been reading—I think you have; I think you have been right at the middle of it. Now, Jack Kemp is running for President, and he says, "The No. 1 part of my platform is to get an early deployment decision." And I am just trying to find out what is happening here. I mean, you are not immune from those pressures.

General ABRAHAMSON. No, sir; I am not.

Senator JOHNSTON. And I think there has been a shift in the program. The numbers show it.

General ABRAHAMSON. There has been. But I got a 36-percent cut last year, and a lot of that was due to your personal efforts. I had to make that somewhere. And I made those based on the valuation of how fast the technology could go ahead where I had the freedom to do exactly that. And what I cut out were things that didn't look like they were going to pay off as well as they might. The whole Excimer laser program is nearly gone. I have kept a very, very little amount of it. [Deleted.]

So I kept a little bit of the technology base and we are proceeding with some of that Excimer laser.

What we have done is we put all of our eggs in one directed energy laser basket and that is the free electron laser.

Senator JOHNSTON. Let me say, by the way, I am not only not opposed to SDI, I support a robust R&D program in SDI; I am strongly opposed to space-based KKV. I mean, testimony I have heard from the best of your experts is that it could be easily defeated. I say "easily" to be not easily, but defeated at less cost and sooner. And the real hope of this program is directed energy weapons. And I think it is being politically driven. That is the thing that—and you are not politically driving it. You are being politically driven on it. And just in case you didn't know—I think you did know—that was my objection on this thing, is to try to keep the—for one thing, a space-based KKV is inconsistent with directed energy weapons in the sense that it takes the funding away. You cannot fund both. I mean, we talk about this as being a phased deployment, as if there is a step. You go step one and then you build on the first step or the second step.

As a matter of fact, in my view, that is not a step at all. You ought to go direct to space based, directed energy weapons. I say "space based"; to directed energy weapons because the first step is going to be easily defeated. All you get with the first step is a very expensive program which, in funding the first program, you do not get the second program. It makes it more difficult later to get there and you get all the difficulties of breaking the treaty.

Just in case you didn't know where I stood on this, I wanted you to understand.

Mr. FOLEY. Let me just add two sentences.

General ABRAHAMSON. I would like to respond.

Sir, that short explanation is more information than I have had about your position since—in the last several years, and I truly appreciate that.

I believe that there truly is a real rationale for both kinds of systems, and I would be delighted to comment and talk to you about it, why you really do need both, and why you should not rely exclusively on directed energy. But I truly appreciate that, because I have not understood where you were coming from. Thank you.

SDI FUNDING REDUCTIONS

Mr. FOLEY. I have no problem following that approach. I had made the statement that I know General Abrahamson would like to have, and sometimes I think there is a misunderstanding, an overall SDI pot in which he moves the bucks around as need be toward directed energy weapons.

Senator JOHNSTON. That is what we have done. We haven't tried to micromanage.

Mr. FOLEY. No.

General ABRAHAMSON. And I really truly appreciate that.

Mr. FOLEY. Well, I am merely saying that in the DOE portion, the directed energy portion, we are taking a large cut, or being given one, out of the SDI program, and there is no way that he could move moneys over toward that if he wanted to.

General ABRAHAMSON. Let me explain that though so that there is not any misinterpretation.

The cut, there are two areas that are cut, but I believe you are referring to the portion that is in the Department of Energy budget.

Mr. FOLEY. The Department of Energy.

General ABRAHAMSON. The Department of Energy budget, meaning the nuclear part of the program. I cannot control that. I did, however, even before the budget was put together. We thought that that was so important that I personally went to the Secretary of Defense, and he worked out with the Secretary of Energy to take part of the mark that was given to the Department of Defense and the Department of Energy, and to shift over an extra $100 million, and to move that over to the Department of Energy budget ahead of time so that when it was presented to the Congress they would have the ability, in fact, to have at least a larger allocation in the R&D budget of the Department of Energy.

All of that will be absolutely lost if we get the kind of cuts in the Department of Energy budget that the House has taken.

Senator JOHNSTON. Well, I cannot imagine, if we are not going to raise taxes and adhere to the Gramm-Rudman target of $108 billion, that there is going to be room to reduce cuts in SDI. There is just going to be room for the kind of increases that the President has in mind. You just cannot get a budget out of nowhere.

TOXIC CONTROL FACILITY, EDWARDS AFB, CALIF.

Now, General, there has been some discussion in Aviation Week, specifically about the use of beryllium in space-based KKV.

General ABRAHAMSON. I have not read this particular one.

Senator JOHNSTON. "A new toxic control facility capable of handling beryllium-based solid rocket propellant used in kinetic energy weapons is planned for construction here." That is at Edwards Air Force Base on a remote 5-acre site.

General ABRAHAMSON. Yes, sir. One of the increases in solid—now this is basic solid propellant technology—is to—right now, if you take the space shuttle and some of our solid propellant motors, what we have are aluminum perchloride as a small—it is sprinkled into the normal solid propellant material. And that increases the ISP, or the thrust, of those particular rockets.

One of the advances is to use a beryllium kind of material, and it is a very exciting advance in the process. And, yes, there is a plan to try to insure that we can build an environment with a safe material and to try to test that.

Senator JOHNSTON. An environmentally safe material?

General ABRAHAMSON. An environmentally safe way of testing that on the surface of the Earth.

Senator JOHNSTON. Testing it?

General ABRAHAMSON. Yes, sir.

Senator JOHNSTON. But there has been no change in the nature of beryllium.

General ABRAHAMSON. No; there hasn't, sir.

Senator JOHNSTON. I mean, it is chemically in nature in there.

General ABRAHAMSON. That's right.

U.S. OUTER SPACE TREATY VIOLATION

Senator JOHNSTON. In your letter to me of April 8, 1987, you said, "The United States adoption of keep-out zones to protect U.S. defensive assets against Soviet space mines would be within the bounds of international law. A Soviet adoption of the keep-out zone over the Soviet Union would violate international law."

Could you give me the basis for this statement?

General ABRAHAMSON. Yes. I think that the U.S. Outer Space Treaty has indicated that, in fact, that space belongs to everybody in terms of that there is no ownership of space over a nation. That has been challenged primarily. Now it may have been challenged in other areas, but in my experience, the main area that it has been challenged was by the nation of Colombia in terms of replacement of communication satellites at geosynchronized orbit directly over their area. Allocation of communication satellites is made in an international body.

Senator JOHNSTON. Yes.

General ABRAHAMSON. That is the only place that I know that that has been challenged.

Senator **Johnston**. But the adoption of keep-out zones to protect the U.S. defensive assets would be within the bounds of international law. I mean, I don't see how it follows that the treaty, which says, in effect, you cannot have sovereignty, allows you to have a keep-out zone around your satellite.

General **Abrahamson**. Because, at least I believe, that that is a matter of negotiations with somebody to try to establish that.

Senator **Johnston**. Oh, I see.

General **Abrahamson**. And it was in that context.

Senator **Johnston**. Oh, I see. In other words, it wouldn't violate international law to negotiate such a treaty with the Soviets.

General **Abrahamson**. Right; that is correct.

Senator **Johnston**. Oh, all right. Yes.

But for us to adopt a keep-out zone——

General **Abrahamson**. You know, I think that becomes a matter of the way you build your system.

Senator **Johnston**. All right.

I have a number of other questions. I don't want to keep you here too long, General. You have been very generous with your time today.

HEAVY LIFT LAUNCH VEHICLE

In your letter of April 8, 1987, you say to me that, "The SDI was not pursuing a hurry-up schedule for the Heavy Lift Launch Vehicle effort," but you requested an emergency supplemental appropriation for fiscal year 1987 of $110 million for the heavy lift launch vehicle.

Senate testimony by NASA and Air Force indicate that you want a heavy lift launch vehicle out at sea on a date of 1992 to 1993, when last year the heavy lift rocket market was planned for the late 1990's. This is quite an adjustment forward of the date. Isn't that, in fact, a hurry-up schedule?

General **Abrahamson**. I think we are talking about what are the semantics of a hurry-up schedule. It is certainly different than the schedule before that, by the way, the pressure from NASA, because the context of my answer was the context of the staff studies or the studies that we have done both within the context of Air Force requirements that are non-SDI requirements. SDI requirements, if there were to be a decision to go ahead—and that was based on the 1994–95 timeframe, which——

Senator **Johnston**. Well, what Air Force requirements are you talking about?

General **Abrahamson**. Well, the Air Force has a set of requirements that they have outlined in this set of studies that are for larger or more capable satellites. And what they have said is that if there were a heavy lift launch vehicle that was available, then they would utilize those——

Senator **Johnston**. For [deleted].

General **Abrahamson**. A certain number for other security missions.

Senator **Johnston**. [Deleted.]

General Abrahamson. I understand. I think the point that they are making is that the Air Force is saying that they have no clear requirement, known requirement, right now. But, if you were able to have lower costs, they have identified a series that could come in the latter half of the 1990's. And I can provide you what that looks like from that study. I don't remember exactly what the timeframe was. I didn't pay that much attention to it.

[The information follows:]

USAF advanced launch system requirement

Payloads	*ALS compatibility*
Milstar	At block II
BSTS	First satellite
SBR	First satellite
DSCS	At block 3C
DMSP	At block 6
NROSS (support)	At block change
Follow-on UHF (support)	First satellite
STP	Investigate
Potential	

In addition to assured access to space, the ALS will facilitate the following improvements:

Low-cost launch; higher reliability launches; responsive surge and call-up capability in crisis; flexibility in meeting GEO requirements; heavier lift for power sources and repair on orbit; survivability (shielding, maneuver, shoot-back, etc.); storage in high orbits; enable orbit changes; and increased onboard payload fuel for longer mission life.

Senator Johnston. Well, what I call a hurry-up schedule, that is from the late 1990's to 1992, was it?

General Abrahamson. NASA has also said that in terms of the space station itself, that they do not have a requirement for a heavy lift launch vehicle in order to support that station. However, if a heavy lift launch vehicle were available, it would profoundly affect their ability to both build a station and to support it.

Senator Johnston. Well, really they say phase 2 after the first $10-something billion.

General Abrahamson. I can tell you that in my discussions with Dale Meyers, as we talk about what ought to be a way that we should jointly, as a nation, proceed on a national requirement—and that is what I think a heavy lift launch vehicle truly is—that the pressure from NASA is to have some version that is available in that 1992 to 1994 timeframe.

Senator Johnston. My conversations with NASA, before they got Secretary Aldrich's letters, were they have no requirements for the space station.

General Abrahamson. Yes; and I think that that is a good point.

Senator Johnston. Later, they changed their tune when they got their marching orders.

General Abrahamson. Well, I don't believe they got a marching order. They say that there is the possibility of a new national initiative.

Senator JOHNSTON. I support a heavy lift launch vehicle, but not before its time. But I don't want to proceed prematurely again and lock us into early outdated technologies. In other words, I don't want the heavy lift decisions to be prematurely made as I don't want the SDI decisions to be prematurely made, locking us into a certain set of technologies now available.

I also wonder how we can do it that quickly, considering how long it took to develop the space shuttle.

General ABRAHAMSON. Well, sir, I think that the real issue here is what kind of technologies really will allow us both the operational flexibility and the low cost that you really like. Some of the ideas that came out in this study that we have been doing for 1½ years—and that was the context of my answer to you, you know, it was a dawn-long study, and, frankly, not all that productive—but our very high technology solutions. There are also low technology solutions that may well be available. And if you will see the emphasis in that PRDA which is available, is an emphasis on not only understanding the cost of the vehicle, a design of the vehicle, but understanding the whole infrastructure of industry behind it, and how, indeed, you have a very reasonable way that you can go through manufacturing tests, and then safely and quickly to a flexible launch operation. And that is based on my personal experience with the shuttle, which I agree with you. We don't want to have that kind of a problem again.

So that the answers to how you get there really depend on getting a group of different ideas in, not just the high technology ideas in. There is another merit in this two-phased kind of concept, and that merit is that if you assume that it is a high technology solution only, and you want to wait only for that high technology solution, you are going to make a very large investment over a long period of time in order to get there before you get any payback.

The phased solution that says create the design that will allow you to get there eventually and get that very low cost. But if there are some interim steps that you get a partial economic payback, then you begin to get payback, if you need it, obviously—and, of course, if you need it is a major question yet—but you do begin to get economic payback as you are phasing in your R&D investment. And I think that that makes sense, if you can begin to get that payback early.

Senator JOHNSTON. Yes; that's right.

General ABRAHAMSON. So it is premature to judge——

Senator JOHNSTON. But certainly if we go forward with these decisions we sort of take the Orient Express—we lock ourselves into a glorified Titan, I guess, or something like that.

General ABRAHAMSON. Of course.

Some of the ideas, by the way, are not even a glorified Titan. They are really big, dumb boosters. And I am waiting with great interest, in fact, how industry is going to respond and to see some of the variations between high and low type of solutions. And that is why that is being deemed exactly the way it is.

Senator JOHNSTON. I want to make clear also, I don't think we ought to try to micromanage these decisions here. I cannot know enough. We in the Congress cannot know enough about the science and about the management of these highly technical programs. And even if we did know enough today, tomorrow that would change, and we should not be in that business.

On the other hand, my concern is that we guard against ideologically driven science, because ideology cannot change science, it cannot change arithmetic, it cannot change physics. And I want the scientists to make that based on scientific judgments and not based on ideology. I hope that is not—I don't think you all are ideologs. And I have some good friends who are, who consider me to be an ideolog of another stripe. But I want the scientists to decide these things. And I have great respect for our scientific people, some which I agree with most of the time and some which I don't always agree with. But they are a great national resource.

Well, General, you have been, as I say, generous with your time, as you have, Admiral Foley. Would either one of you like to add anything before we conclude?

General ABRAHAMSON. I am kind of sorry, sir, that it became so SDI oriented because it is really Admiral Foley's hearing.

Mr. FOLEY. No; SDI is our No. 1 R&D priority. We talked about this before. And I am not going to be able to meet General Abrahamson's milestones. And I don't like that. I will tell you quite personally, I don't like being unable to meet his milestones and I don't like being unable to put this complex in the kind of condition that I think it ought to be in. And I have said that we cannot compress any more. We are going to have to shut things down and not meet the DOD requirements, and not make this a little bit more robust and expand that margin of safety. And I am unwilling to be a party to that.

Senator JOHNSTON. Why don't you, by the way, send us up a budget amendment for these high-priority activities? Because I support them. I mean, we ought to get it right out front, because you try to add one of these things to the budget when momentum is in the opposite direction will be hard. I mean, what I hear from you all about budgets, we hear about regarding many other programs.

Mr. FOLEY. I understand.

Senator JOHNSTON. And if you don't have a budget request, then it makes it that much more difficult.

Do you all have access to the programs you need? You said that our people could have access to any of these architectures.

General ABRAHAMSON. We have access to the architecture studies, that kind of information. There are certain programs that you will not.

Mr. BRUCE. Is it the zero one architecture study?

General ABRAHAMSON. Pardon me.

Mr. BRUCE. Is it the zero one architecture study?

General ABRAHAMSON. The zero one architecture study, of course, is being modified and changed as we go. If you would like to look at some of that, they are available. But I can tell you, I would appreciate it if you would come to us for it rather than around to everybody else.

Senator JOHNSTON. I would appreciate that. Well, that is good.

Thank you very much.

General ABRAHAMSON. Yes, sir.

ADDITIONAL QUESTIONS FOR THE RECORD

Senator JOHNSTON. Now, Senator McClure has some questions he would like answered for the record.

[The questions and answers follow:]

QUESTIONS SUBMITTED BY SENATOR MCCLURE

Strategic Defense Initiative

Question: Has the Strategic Defense Initiative Office reoriented its program to vigorously pursue near-term deployment?

Answer: The Strategic Defense Initiative Organization has not shifted its budget to support near-term options. The Strategic Defense Initiative (SDI) research charter continues to address the spectrum of mature and advanced technology research. We have placed emphasis where it is considered most critical, such as the shortfall in space transportation. We have also rebalanced the complicated resource allocation plan based on actual appropriations and the need to maintain competition in technology approaches. Our goal remains, however, to continue to pursue a delicately balanced program.

Question: I have reason to believe the SDl program has made some significant progress over the past three years. Will you give us some examples?

Answer: There has been considerable technical progress in the SDI program over the past few years as should be expected from an investment of several billion dollars in over 2,000 contracts. Let me list for your attention a few areas that do carry with them the promise to provide the country with the technology to render a Soviet ballistic missile of much lower value as the President has envisioned.

First, the Kinetic Energy Office has funded the Draper Laboratories who developed a resonating fiber optic gyro that makes possible miniaturized inertial measurement units (IMU) of extremely high accuracy, possibly for less than $4,000 per unit. This is indeed a breakthrough and has impacts that far exceed its usefulness on Exo-Atmospheric Reentry Vehicle Interceptor Subsystems (ERIS) and Space-Based Kinetic Kill Vehicles (SBKKV) in making these systems technically viable and more cost effective. An IMU of this type can be directly integrated into tactical weapons systems at an affordable price; this has the potential of revolutionizing the capability of "smart" conventional defense systems. In fact, having such inexpensive units should allow the private aviation sector to equip small aircraft, improving safety and efficiency.

Another area impacting SBVVK technology is the development of thrust control valves, for rocket divert maneuvers, that operate in less than 1 millisecond--a factor of 10 improvement in the state-of-the-art and a key factor in establishing the viability of SBKKV technical feasibility.

In the area of directed energy research, we have seen the operation of high brightness negative ion sources (for neutral particle beams) of weapons-capable quality and operational times of over 30 seconds. In addition, a completely remote-controlled startup operation and shutdown of a neutral particle beam injector and extractor was demonstrated. This was an essential step in having a space based neutral particle beam available in the 1990's.

The SDI program has funded the commercial development of radiofrequency power sources that weigh as little as 0.3 grams/watt. The applications for this technology far exceed the space-based SDI system needs.

The SDI Sensors Program has developed a major new radiation hardened infrared detector technology, called impurity band conduction (IBC). This should all but lock-in the technical viability of providing a sensor system to perform some SDI missions even in the presence of severe radiation environments.

There are many other technical advances that could be added such as diamond coating for optics, and the Sol-gel low temperature glass formation technology. However, I believe one can clearly see that not only has there been clear "measured" progress made in the scientific, engineering, and systems integration areas, but that major accomplishments of fundamental importance to establishing the technical feasibility of SDI have also been produced.

Question: Isn't the work the SDIO is doing helping support and contribute to a national broad technology capability?

Answer: The SDI research program is helping support and contribute to a national broad technology capability through its support of university and small business research. Many of the early predictions by critics of loss of academic freedom, classification of campus research, and restrictions on foreign graduate students working on unclassified projects have been demonstrated to be incorrect. While there is still opposition from some in academic circles, it represents a minority of professors in the scientific, engineering, and computing departments throughout the research institutions in this country.

The impact of the SDIO program on universities is both large and small. Small in the sense that the total SDIO dollars for basic research at universities is about 10 percent of the Department of Defense total or about 1 percent of the total U.S. government, with NASA, NSF, Department of Energy, and NIH all contributing more than 10 percent of the total. In addition, a recent National Academy of Engineering report states that increases in DOD research budgets are unlikely to create shortages in manpower for non-military needs. The impact is large in that SDIO contracts represent the only really new money for research recently. Because of the new program, new researchers with new innovative ideas have a greater chance of being funded. Much of the SDIO money is going toward purchases of new equipment or equipment upgrades in university laboratories cursed with outdated material. Finally, because of the nature of the high risk/high payoff research funded by the Innovative Science and Technology (IST) Office, many very innovative ideas which would not receive support from existing agencies are being funded. This investment strategy will allow many technologies to leapfrog into twenty-first century science within the next decade.

In addition to the IST effort, there are significant technology and system "spinoff" opportunities provided by numerous ongoing SDIO projects that are relevant to our conventional non-nuclear military capability. Some of the more promising SDI development, many with fairly near-term application to conventional defense, are: electromagnetic guns ("rail guns") that launch guided and unguided projectiles at velocities far exceeding existing conventional guns; optical (infrared, ultraviolet, and visible spectrum) and radiofrequency sensors that can detect, identify, and track low-observable targets at long ranges in a severe jamming environment, and can lead to superior multispectral seekers for making our tactical missiles "smarter"; advanced communications, multiprocessors, and computer software that will permit reliable and affordable command and control over large and widely distributed land, sea, and space forces; lasers that can rapidly destroy hardened targets or burn out vulnerable optical sensors at long ranges; and advanced computational techniques and test facilities that can be used to estimate, measure, and project the vulnerability of missiles and other targets to kinetic energy and laser weapons.

Question: The FY 1987 Continuing Resolution significantly cut the amount requested by the SDIO. What effect did this cut have on the national laboratories? What effect would similar cuts this year have on the national laboratories?

Answer: SDIO spent approximately $300 million a year in FY 1986 and FY 1987 through the national laboratories on a reimbursable basis. Overall, the national laboratories had essentially no real growth due to the significant reduction from the SDIO FY 1987 budget request. However, individual national laboratories did have program reductions. The lack of a real increase partially contributed to a reduction in manpower at the Los Alamos National Laboratory. Similar reductions to the FY 1988 SDIO budget request, coupled with reductions to the DOE budget, could lead to significant manpower reductions at the national laboratories.

SUBCOMMITTEE RECESS

Senator JOHNSTON. With that, the subcommittee will recess subject to the call of the Chair.

[Whereupon, at 12:30 p.m. Thursday, April 23, the subcommittee was recessed to reconvene at the call of the Chair.]

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